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THE MINERALOGICAL SOCIETY

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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, November 19th, 1895.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Mr. R. C. Webb and the Rev. Mark Fletcher were elected Ordinary Members of the Society.

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, November 19th, 1895.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Seventeen Members and three visitors were present.

The following Report of Council for the Session 1894-5 was read by the Secretary :—

REPORT.

The Balance Sheet for the year ending December 31st, 1894, which was issued with Number 49 of the Journal, showed that the state of the finances of the Society continued to be eminently satisfactory : the Assets (exclusive of the Stock of the Journal and the Library) amounting to £382 6s. 1½d. The number of existing Members who had compounded before December 31st, 1894, for their Annual Subscription was 37.

During the Session 1894-5, one Member, Mr. Patrick Dudgeon, for many years a Trustee of the invested funds of the Society, has been removed by death ; two new Members have been elected ; two Corresponding Members (Professors Johnstrup and J. D. Dana) have died ; and three new Corresponding Members (Dr. Brezina, Professors Klein and Brögger) have been added to the List. The number of Members of the Society is now 132 : of these, 110 are Ordinary Members and 22 are Corresponding Members.

Mr. R. H. Scott, M.A., F.R.S., Past-President of the Society, was appointed to the Trusteeship vacated through the death of Mr. Dudgeon.

Four Meetings have been held during the year, all in London, and (by kind permission) in the Apartments of the Geological Society, Burlington House.

Two Numbers of the Journal, Nos. 49 and 50, have been issued since the last Anniversary Meeting. The principal papers in No. 49 were those by Professor Church and Messrs. Prior and Spencer. The former author gave the Society an account of various researches which he had made into the chemical composition of certain native arsenates and phosphates, particular attention being paid to the degree of tenacity with which the water of the hydrous species was held: Professor Church also described a basic ferric sulphate from Anglesey. Messrs. Prior and Spencer gave a careful description, chemical and crystallographic, of a rare mineral from Bolivia, Augelite, a hydrous aluminium phosphate. To the same Number Professor Bonney contributed a note on cone-in-cone structure, pointing out that the structure, though primarily due to crystallisation, owes its development to contraction subsequent thereto. Mr. Dudgeon placed on record the occurrence of mispickel in the Stewartry of Kirkcudbright, and Professor Heddle and Mr. Thomson described the mode of occurrence and the characters of Delessite in Cantyre. No. 50 contained an important paper by Professor Judd, in which he showed that corundum has three sets of structure-planes, but that none of them can be regarded as true cleavage. The same author described the occurrence of corundum-rock, and of other large masses, each consisting essentially of material belonging to a single mineral species. The Earl of Berkeley contributed the result of his study of the methods of accurately determining the densities of crystals. An elaborate paper by Mr. Spencer recorded his researches into the mineralogical characters of Enargite; while Dr. Hussak and Mr. Prior described two new minerals—Lewisite, a titano-antimonate of calcium and iron; and Zirkelite, a zirconate and titanate of calcium.

The Abstracts in the two Numbers have been of an interesting and useful character: for these the Society is indebted to the kindness of Messrs. Harker and Spencer.

On the motion of the Chairman, seconded by Mr. Scott, the Report of the Council was adopted.

Mr. Rudler and Mr. Pringle were nominated scrutineers; they reported that 28 voting papers had been returned, and that the following list of Officers and Council had been unanimously approved

President.	Prof. N. S. Maskelyne, F.R.S.
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	Mr. A. Hutchinson, M.A., Ph.D.
	Mr. B. Kitto, F.G.S.
	Lieut.-Gen. C. A. McMahon, F.G.S.

In addition to the members not requiring re-election, Prof. Green, Mr. Harker, Prof. Lewis, Mr. Pringle, Mr. Prior, Mr. Thomson, Mr. Tutton and Mr. Watts; and in place of the retiring Members, Prof. Church, Prof. Le Neve Foster, Mr. Miers and Prof. Macadam.

Messrs. J. H. Collins and B. Kitto were elected Auditors of the accounts of the Society.

A vote of thanks to the Geological Society for the use of its Apartments was carried with acclamation.

The following paper was read :—

On Homogeneous Structures and the symmetrical partitioning of them: by Mr. William Barlow, F.G.S. [p. 119]. The paper was illustrated by numerous models: Professor Herschel submitted for inspection a large series of models bearing upon the same subject.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, February 4th, 1896.

Mr. W. W. Watts, M.A., F.G.S., in the Chair.

The resignation of Mr. Vaughan Hughes was accepted.

GENERAL MEETING.

Held in the Apartments of the Geological Society, February 4th, 1896.

Mr. W. W. Watts, M.A., F.G.S., in the Chair.

Thirteen Members were present.

The following papers were read :—

1. On fibrous and massive forms of Calcite and Aragonite: by Mr. L. J. Spencer.

2. On associated globular and rhombohedral forms from Botallack, Cornwall: by Mr. F. Rutley.

3. On the occurrence of rocks allied to Monchiquite at Fernando Noronha: by Mr. G. T. Prior.

4. On a method of determining the optic axial angle in cases where plate is oblique to a bisectrix: by Mr. W. J Pope.

Specimens were exhibited in illustration of the last three papers. Mr. Pope also demonstrated the phosphorescence resulting from fracture of crystals of saccharin, a property of the substance discovered by him.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, April 14th, 1896.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

The resignation of Mr. Townshend Hall was announced.

GENERAL MEETING.

Held in the Apartments of the Geological Society, April 14th, 1896.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Fifteen Members and two visitors were present.

The following papers read :—

1. Some lecture-room apparatus for illustrating the elementary principles of Crystallography: by Mr. C. J. Woodward.

2. On Wolfsbergite from Bolivia, and the probable identity of Wolfsbergite and Guejarite : by Mr. L. J. Spencer.

3. On some hitherto undescribed British pseudomorphs : by Professor H. A. Miers.

4. Note on the relations of Enstatite and Olivine to the Humite group: by Professor W. J. Lewis.

5. On the Micas of the Three Rock Mountain, County Dublin, and on the presence of copper in the mica of Glencullen, County Wicklow: by Professor J. P. O'Reilly (communicated by Mr. F. Rutley).

Mr. Woodward showed a convenient method of marking zones on a blackened india-rubber ball, constructed crystal figures on a blackboard by stretching coloured elastic bands round pins inserted at particular points in the board, and exhibited an adjustable triad of coloured rods representing crystallographic axes.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 23rd, 1896.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

The death of M. Daubrée, corresponding Member, was announced.

Mr. Louis Wills was elected to the ordinary Membership of the Society.

Mr. Barlow, Prof. Church, Mr. Miers, Mr. Pope, were selected for nomination to replace the four retiring Members of the Council (Messrs. Lewis, Pringle, Prior and Thomson).

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 23rd, 1896.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Fourteen Members were present.

The following papers were read:—

1. Notes on a biotite-cyanite-cordierite rock from the Upper Satlej Valley, N.W. Himalayas: by Lieut.-Gen. C. A. McMahon, V.P.G.S. [p. 141].

2. Homogeneous structures that cannot be partitioned into cells which are all of the same shape without impairing the symmetry (illustrated by models): by William Barlow, Esq.

The Secretary submitted for inspection a specimen of the noble opal from New South Wales, and three specimens of the Swedish mineral reported to be chemically identical with the Scotch Edingtonite, but to be orthorhombic and optically biaxial.

Mineralogical Society—Abstract of Receipts and Payments from 1st January to 31st December 1895.

RECEIPTS.

	£ s. d.	£ s. d.
Balance from year 1894		36 9 8½
Subscriptions:—		
(1) In advance	4 1 0	
(2) Current	49 7 4	
(3) In arrear	11 11 6	
		64 19 10
Entrance Fees and Compositions		47 5 0
Sale of Publications in Office		0 5 8
Dividends on Stock		7 14 0
		£156 14 2½

PAYMENTS.

	£ s. d.	£ s. d.
Printing and Stationery		55 7 3
Illustrations		0 18 0
Binding Books for Library		6 2 0
Attendance at Meetings		1 1 0
Insurance of Stock		3 2 6
Investments and Commission		6 18 6
Fees in connection with change of Trustee		0 15 6
Commission on Cheques		0 2 0
Balance at Bank	£82 3 3	
In Office	0 4 2½	
		82 7 5½
		£156 14 2½

Examined and compared with the vouchers and found correct. (Signed)

February 13th, 1896.

BENEDICT KITTO, } *Auditors.*
J. H. COLLINS, }

LIABILITIES.

	£ s. d.	£ s. d.
Secretarial Postage		1 6 5
Excess of Assets over Liabilities		459 10 11½
		£460 17 4½

The number of Life Members on December 31st, 1895, was 34.

ASSETS.

	£ s. d.	£ s. d.
Balance as above		82 7 5½
Subscriptions for 1893-5 unpaid		10 0 0
Stock in 2¾ Consols: £293 12s. 2d. at 108		317 3 0
Dividend on Stock, January 1896		1 19 0
Sale of Journal due from Publishers, 1894		16 17 5
Ditto ditto 1895		24 16 11
Due for Authors' Copies		7 13 7
		£460 17 4½

Memo.—The Stock of Publications and the Library are not included in the above assets.

(Signed) F. W. RUDLER,

Treasurer.

THE MINERALOGICAL MAGAZINE

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MINERALOGICAL SOCIETY.

No. 51. OCTOBER 1896. Vol. XI.

On Homogeneous Structures and the Symmetrical Partitioning of them, with application to Crystals.

By William Barlow.

[Read November 19th, 1895.]

AT the outset we have to consider what constitutes homogeneity of structure.

First, it may be noted that it is not to be confounded with *structureless homogeneity*.

The completest homogeneity conceivable is presented when at *every geometrical point* in space the qualities are the same; but when this is the case, structure is absent, and no property can be displayed depending on differences of any kind which enable us to distinguish one point from another, however infinitesimal the distance separating the points compared. Homogeneity of structure consists, not in the same qualities being presented at every geometrical point of a body, but in the similar repetition of the same qualities or forms throughout it.

In Thomson and Tait's treatise on Natural Philosophy we read, "A body is called homogeneous when any two equal, similar parts of it, with corresponding lines parallel and turned towards the same parts, are undistinguishable from one another by any difference in quality;" but this definition, when applied to a homogeneous structure, cannot be other than empirical and not mathematically precise, its truth depending on the tests applied not being refined enough to detect ultimate discontinuity of constitution of the structure.[1] It may be said, as applied to such a structure, to describe an apparent property rather than to lay down a geometrical definition. The writer has endeavoured to frame a definition of homogeneity of structure which shall be mathematically exact, and free from any needless limitation, and recently propounded the following:[2] "A homogeneous structure is one every point within which, if we regard the structure as without boundaries, has corresponding to it an infinitude of other points whose situations in the structure are precisely similar, so that all of the infinite number of geometrical point-systems respectively obtained by taking all similarly situated points are regular infinite point-systems, defined by Sohncke as systems of points such that the arrangement about any one of these points of the rest of the points of the system is the same as it is about any other of them."[3]

It may be remarked in this connection that the conception of a system of points or atoms which repeats itself in the way indicated presented itself independently to both Sohncke and Wiener.[4]

Here are some models which I have constructed to show some of the least complicated types of homogeneous structure of the cubic system, and which will, I hope, make my position clearer; and in reference to them I may say that my mind has been exercised in attempts to portray the nature of the repetition which constitutes homogeneity of structure in the most general way possible, and especially to avoid anything which seems to imply atomicity, proof of the existence of which must, it would appear, be sought elsewhere than in the geometry of crystals, *i.e.* of homogeneous structures.

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[1] Fedorow cites some evidences of discontinuity of structure of crystals. See *Theorie der Krystallstruktur* in *Zeitschr. für Kryst. &c.* XXV. p. 116. Comp. Thomson and Tait, II. p. 216.

[2] *Zeitschr. für Kryst. &c.* XXIII. p. 1.

[3] Sohncke's *Entwickelung einer Theorie der Krystallstruktur*, p. 28. Those kinds of repetition in space the repeating parts of which have some dimension infinite, are not included in this inquiry.

[4] Comp. Wiener's *Grundzüge der Weltordnung*. Leipzig, 1869. Atomlehre, p. 82.

With this purpose before me, I have, in devising my models, avoided the use of particles or spheres, and have placed a quite irregular body, a hand,[1] in the positions appropriate for showing the kind of repetition characteristic of a given type.

This model (a cubic element of which is shown diagrammatically in fig. 1) gives a certain very regular type of cubic symmetry, that which is marked $7a_1$ in the lists of homogeneous structures to be found in the memoir above referred to.[2] It belongs to Class 31 (dodecahedral hemihedry) in Sohncke's list of 32 classes of crystal symmetry.[3] The structure contains left hands as well as right hands, because it is one of those that are identical with their own mirror-images, and consequently made up of parts enantiomorphically related. It is formed of a number of similar groups of the kind shown, the cubes containing which are fitted together to fill space symmetrically.

In the actual model each such cubic element is composed of eight *cubelets*, the edges of which are formed of strips of wood meeting at the corners of the cubelet, and the latter having also one of its four diagonals occupied by a strip of wood on which three hands are hung symmetrically.

Thus each cubelet contains three of the 24 hands found in a single element, four alternate cubelets being similarly occupied by right hands, the remaining four by left hands. The entire structure is therefore built up of cubelets of two kinds, with their respective triads of hands.

The eight single diagonals of the eight cubelets of an element meet in a point at its centre.

The cubic partitioning thus indicated is, however, not essential, and is to be regarded as mere scaffolding, and as having fulfilled its object in keeping the hands in their places, and in enabling us better to perceive the nature of their arrangement; *indeed, the type of homogeneity is expressed in a more general manner when there is no partitioning at all.*[4]

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[1] Comp. Fedorow, *Zeitschr. für Kryst.* XXV. p. 115. The employment of hands was suggested to me by Prof. Miers; its advantages are that the use of so familiar an object greatly facilitates a clear perception of the nature of the arrangement, and that the shape is so exceptional that no one can be led to imagine it to be a necessary feature of any type.

[2] *Zeitschr. für Kryst.* XXIII. p. 44.

[3] *Zeitschr. für Kryst.* XX. p. 467.

[4] This is true of all the types. The same homogeneous structure can, in most cases, be partitioned in a manner compatible with the preservation of its homogeneity and symmetry *in an infinite number of ways.* The cubic partitioning resorted to in the case under consideration is a very arbitrary one, and a structure of the given type need not have any characteristics corresponding to the *exceptional* symmetry which this kind of partitioning produces.

As we shall see presently, there are cases of homogeneous structure in which *no*

In the case before us, the edges of the cubelets are digonal axes of rotation of the structure, *i.e.* when the structure is turned through 180° about one of them, all its parts in the new position coincide with all its parts in the old. The positions of the planes of symmetry of the structure, as well as those of the various axes, are readily traceable when a number of composite cubic groups of the kind described are stacked together.

The right hands are distributed homogeneously, and so are the left hands, and, in obedience to the definition above given, any set of similar points, *e.g.* the tips of the thumbs, or the tips of the first fingers of either right hands or left hands, form a Sohnckian point-system. If we take corresponding points of both right and left hands, we obtain the double point-systems of Fedorow. The single point-systems traceable in this type are those described by Sohncke as No. 54; it is easy to see that all the points in any one of them have the fundamental property of a regular infinite point-system; they bear identically the same relation to the infinite structure considered without reference to the horizon, or the north pole, or indeed anything other than the homogeneous structure itself.

One of the simplest possible examples of this type of structure will be obtained if we make a stack of similar bricks in the following way; and to make the description simpler, we will employ bricks whose width and thickness are respectively half and quarter of the length.

Stand two bricks on end opposite and parallel, with a space between them of the width of a brick, the two thicknesses and the space together thus making up the length of a brick.

In the space lay a brick flat, so as to project the thickness of a brick on each side beyond the two first placed.

On the projecting ends of this brick stand two bricks on edge, with their overhanging ends even with the faces of the two first placed.

Finally, place a brick flat directly over the middle one, with its ends resting on the two last placed.

The outline of the pile thus formed will be a cube, except that a cube-shaped vacancy will be left at each of the eight corners. There will also be a cubic cell left in the middle.

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kind of partitioning *into single units* (*i.e.* not of two kinds which are enantiomorphs) is possible *which does not impair the symmetry and alter the type of homogeneity*. (See p. 132 and $2b_1$ and $6b_2$ in table on p. 135).

Some suggestions for the classification of the different kinds of *symmetrical* partitioning possible will be made presently.

Stack together a number of cubic elements of this kind similarly orientated, with the cubes of succeeding layers directly over one another. The homogeneous structure obtained is an example of the type above given.

As the outside faces of the bricks of each cubic element coincide with the faces of those in contact with it belonging to the adjoining elements, the stack may be regarded as composed of pairs of bricks, each pair consisting of two bricks placed face to face. No change of type will therefore be involved if, instead of pairs of bricks, single bricks of double the size are used, *i.e.* such as have width and thickness equal, and each equivalent to half the length. Each double brick will then fill the space previously occupied by two of the thinner ones.

Other types of homogeneous structure also of the cubic system are represented by these remaining models, composed of hands appropriately arranged.

Thus we have :—

Type 7, a representative of Class 32, the tetartohedral cubic (an element of this structure is represented by fig. 2). Of the eight cubelets which compose the element, four are those containing right hands (or left hands), and the remaining four are empty.

Type $7b_1$, a representative of Class 30, tetrahedral hemihedry (an element is represented by fig. 3). Of the eight cubelets composing the element, four contain both right and left hands symmetrically placed, and four are empty.

Type 12, a representative of Class 29, the gyrohedral cubic (an element is represented by fig. 4). The eight cubelets composing the element, all contain right hands or all left hands.

Type $12a_1$, a representative of Class 28, the holohedral cubic (an element is represented by fig. 5). The eight cubelets comprising the element all contain both right hands and left hands.

The simplest possible example of a structure of the last-named type is presented by a cubic partitioning of space whose cells *are empty*. We have too an extremely simple example of this type in a cubic Raumgitter.

Here, too, are some types of structure which are most conveniently constructed by packing close together cells which are respectively dodecahedra and cubo-octahedra, but as before the cellular construction is to be regarded as mere scaffolding.

Type 6. This, like type 7, is a representative of Class 32, the tetartohedral cubic (an element contained in a dodecahedral cell is represented by fig. 6). This type can also be built up of cubelets, but there will be a larger number of empty ones than in the former cases.

Type 10. This also, like type 7, is a representative of Class 32, the tetartohedral cubic (an element contained in a cubo-octahedral cell is represented by fig. 7).

If cubelets with a single diagonal are employed to build up this type, they must each contain three right hands or three left hands appropriately placed, cubelets which have a common diagonal being everywhere found similarly orientated.

The element contained in the dodecahedral cell of type 6 is precisely of the same kind as that contained in the cubo-octahedral cell of type 10. Similar points form, in both cases, 12-punkters of Sohncke.

Cubelets with a single diagonal, of the kinds above described, can also be employed to construct the less-regular types of structure of the cubic system.

In the memoir referred to[1] I have made an investigation of all the possible types of structure which fulfil the definition given above. The result shows that all homogeneous structures have a general symmetry which is strictly paralleled by the symmetry of crystals. And, while it is true that the definition laid down does not express any limitation regarding the relative orientations of the similar parts[2] whose likeness constitutes the homogeneity, much less require the orientations to be identically the same, as is the case with some of the older definitions of homogeneity, we discover that similar portions of a homogeneous structure always have a definite number of symmetrically related orientations, depending on which among the 32 classes of crystal symmetry the structure selected belongs to.

And this number is that of the different orientations of the ideal crystal form which can be made and give coincidence of outline. It is therefore in some but 1; in others 2, 3, 4, 6, 8, 12, or 24, as the case may be.

The relation of the orientations of similar parts just referred to *should not, therefore, be made a matter of definition, but of proof.* If a likeness of parts obeying the definition which I have given existed which did not give the symmetrical relative orientations referred to, it would notwithstanding be an example of homogeneity of structure; but, in fact, as I have just intimated, there is no exception, the only case where there is homogeneity without symmetrically related orientation of similar parts being that of structureless homogeneity.

[1] As corrected in some few particulars in an article in the same journal, Vol. XXV. p. 86.

[2] By similar parts is meant parts similarly related to the whole.

There is a more uniform quite universal property of homogeneous structures, which may be expressed in much the same words as those of Thomson and Tait's definition quoted above.

Thus, such a structure can always be regarded as made up of equal, similar, sameways-orientated parts, which are undistinguishable from one another by any difference in quality.[1]

Each of the parts thus related will consist of an integral number, large or small, of space-units[2] of the structure of some kind or other. In the case of a structure with anorthic symmetry, it may comprise but one space-unit only. The distances between corresponding points of two such adjoining parts will be those between the corresponding points of some two contiguous or more or less widely separated space-units *whose orientation is the same.*

The outlines of the parts thus related will generally not constitute a partitioning which can represent any possible natural partitioning of crystals into chemical molecules, or into crystal molecules (if there be such entities distinct from chemical molecules); for, except in a few particular types of cases, the partitioning arrived at in this way will be quite arbitrary, and be incompatible with some of the coincidence-movements (Deckbewegungen[3]) of the structure, and therefore destructive of a portion of its symmetry, and will effect a change of its type.

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[1] Fedorow says, "Das Resultat der Beobachtungen kann auch dahin gedeutet werden, dass die krystallinisch-homogene Substanz aus gleichen und gleich-orientirten (d. h. sämmtlich in paralleler Lage geordneten) Theilchen besteht, welche zusammen genommen den Raum lückenlos ausfüllen."—*Zeitschr. für Kryst.* XXV. p. 117.

[2] The three necessary properties of a space-unit are—(1) it is continuous; (2) it contains every kind of point of the structure (*i.e.* every kind of standpoint from which the structure can be regarded); (3) all the points in it are differently related to the structure as a whole. See *Zeitschr. für Kryst.* XXIII. p. 38.

[3] The following is Sohncke's definition of a coincidence-movement (*Deckbewegung*):—

Suppose a regular infinite point-system (see p. 120 above) to be made rigid, and moved bodily out of its original position. The positions originally occupied by the points of such a system then collectively furnish a point-system which is congruent with the moved system, and which, to distinguish it from the *moveable system*, may be called the *fixed* system.

If now any point of the moveable system be selected, and placed to coincide with any point whatever of those of the fixed system, it is, owing to the congruence of all *Linienbündel*, always possible to bring the two systems to coincidence.

The movement which the moveable system executes in order to pass from one position of coincidence with the fixed system to some other position of coincidence, is called a *Deckbewegung.*

Such Deckbewegungen can be partly parallel translations, partly rotations or screw movements about certain axes definitely placed in the fixed system.

The Deckbewegungen possessed by any particular system will depend on the properties of the system, and indeed the different kinds of point-systems may be

The property referred to is therefore of no great importance as regards the ultimate structure of crystals, although it may possibly aid our conception of the connection between homogeneity of structure and some physical properties.[1]

The definition above given is, as we have seen, not limited in its application to point-systems or assemblages of particles; it may be obeyed by any kind of structure, whether material or merely geometrical, whether filling space or continuously ramifying through it, or distributed through it in discrete patches. It may, too, be obeyed by structures whose parts are in motion, provided the similarity extends to the movement of similar parts; but the similar movements need not be simultaneous.[2]

The number of different types of symmetrical arrangement presented by homogeneous structures is 230;[3] and these types, as we have said, fall into 32 classes, whose general symmetry is of the 32 kinds proper to crystals.

Such an array of possible types may well alarm the crystallographic student, and lead him either to quit the subject of homogeneous symmetry in despair, or to beat about for some pretext which shall justify the exclusion of some of these types, and bring the number available for crystals down to a smaller figure.

I deprecate the latter course, unless the grounds for it are fully adequate; otherwise the very types we exclude may turn out after all to be those which are most suggestive in connection with crystal properties.

The course which seems to me more scientific, and I may add more hopeful, is to seek to become acquainted with the principal features of homogeneous structures generally, *and especially with the numerous geometrical properties which they possess in common.*

The models which I have made are, I think, calculated to give some material help in this direction; even a cursory glance at them reveals such intimate relations and similarities between types which eminent authorities say we may reject for crystallographic purposes, and others

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distinguished according to the Deckbewegungen which are proper to them, so that the different sets of Deckbewegungen presented serve as the ground of the classification of the regular point-systems. (See *Entwickelung einer Theorie, &c.* p. 28. Compare Bravais, "Sur les Systèmes formés par des points distribués régulièrement," *Journ. de l'Ecole Polytechnique, Cahier*, XXXIII. p. 57.)

[1] See below, p. 127.

[2] They may resemble the rhythmically related movements of *combined figure skating.*

[3] This number agrees with the total number of single and double point-systems as ascertained by Fedorow and Schönflies independently.

which they say we may retain, as will at least make us examine very closely, and indeed suspiciously, the grounds on which they consider themselves authorised to discriminate.

I allude more particularly to Fedorow's attempt to select from among the types of homogeneous structure those which are possible for crystals, and to determine the shapes of their ultimate units,[1] in reference to which I cannot but express my regret that so eminent an authority on crystal structure should give the weight of his name to what appear to me to be *a number of wholly untenable limitations*.

Fedorow says that the result of observations of the properties of crystals may be summed up in the proposition that the homogeneous crystal-substance consists of similar, sameways-orientated parts which, taken together, fill space without interstices,[2] and proceeds to argue that some of the 230 types of homogeneous structure are incapable of being thus divided, and must therefore be regarded as impossible for crystals.[3] But is this so? It has already been pointed out above that every homogeneous structure, *without exception*, can be regarded as made up of equal similar, sameways-orientated parts, which are undistinguishable from one another by any difference in quality, and there does not appear to be any reason why a structure possessing this property should not fulfil the experimental requirements of crystal-structure *even in cases where the sameways-orientated parts are merely geometrical ones, the existence of whose boundaries lowers the symmetry of the structure as a whole and alters its type*, and which do not, therefore, represent any separable units (molecules or other).[4]

We have indeed to ask ourselves continually in connection with this and the other contentions of Fedorow, contained in the same treatise, what significance he attaches to his partitioning of a crystal structure? Is it suggested that when a crystal dissolves, its parts will under any circumstances retain shapes which, if fitted together, fill space, or, to put it more precisely, that the solid angles and edges of the cells are none of them vacuous or structureless in the unbroken structure, but always occupied by matter which, when the structure breaks up, can retain its situation relatively to other matter belonging to the same cell? Such a

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[1] Fedorow's *Theorie der Krystallstruktur. Mögliche Strukturarten. Zeitschr. für Kryst.* XXV. p. 113.

[2] *Zeitschr. für Kryst.* XXV. p. 117.

[3] *Ibid.* See especially p. 218.

Cases of this kind are presented by types 3 and 4 in my list. *Zeitschr. für Kryst.* XXIII. p. 11. Compare below, pp. 128 and 135.

proposition is so unlikely that to state it is almost to refute it. Certainly we cannot, until evidence is forthcoming, assume that there is any truth in it.

But if, as is then almost certain, the partitioning into cells of a definite outline capable of filling space is, in the case of crystals, *a mere geometrical fiction*, what stress can be laid on the relative inclinations of the plane-faces of the cells,[1] or how can re-entrant angles be argued to be unlikely, or indeed what significance is there in the cell-walls having plane-faces at all ?

If a particular partitioning has no strict counterpart in a crystal, but simply expresses the nature of its divisibility into units or molecules in a general manner, the presence of a re-entrant angle in a cell wall would merely represent that the outline or boundary of one composite unit or molecule fits into that of an adjoining one like the parts of a carpenter's "dovetail," or like a tenon into a mortise, a conception by no means startling or improbable when taken in as general a sense as possible.

We cannot, therefore, concur with Fedorow in his rejection of those asymmorphous types which cannot be partitioned into similar cells with similar contents, whose *outline*[2] *displays the complete symmetry of the entire structure*, or accept his reasons for regarding as unlikely for crystals cases where the partitioning into plane-faced cells gives either (*a*) abnormal (anomale) parallelohedra, *i.e.* parallelohedra whose form is such that no kind of homogeneous deformation reduces them to the most symmetrical forms of crystal symmetry,[3] or (*b*) re-entrant angles between the plane walls of a cell,[4] or (*c*) cells whose external boundaries are similarly orientated, while the contents of the cells are not.[5]

It is true that Fedorow's classification of homogeneous structures under three heads—symmorphous, hemi-symmorphous, and asymmorphous systems—marks geometrical differences whose nature is thus

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[1] Fedorow distinguishes "normale" and "anomale" parallelohedra (see below).

[2] Comp. Fedorow, *Zeitschr. &c.* XXV. Note*, p. 147.

[3] *Ib.* p. 132.

[4] *Ib.* p. 133.

[5] Fedorow calls these "extraordinär," those whose contents and outlines are alike sameways-orientated "ordinär" (see p. 135).

The suggestion made by this author (p. 146) that cases of the "extraordinären" kind are unlikely, because it is inconceivable why the contents of the cells should be differently orientated, does not help his contention, because, if there is this difficulty in accounting for various orientations of the composite elements of a mass, *there is also the same kind of difficulty* in accounting for the similar parts of any such element being put together with their orientations various, and the latter is an essential condition in most homogeneous structures.

appropriately indicated, and that his other distinctions are also based on geometrical facts; but this does not strengthen his position so long as he fails to bring forward any evidence which is even plausible that any one of the classes of a highly specialised nature which he discriminates is more likely than another to be present in crystals.[1]

Instead of dwelling on differences between the various kinds of plane-faced cells—an investigation which may or may not ultimately prove to be of any importance—we ought, as it seems to me, to strive after some altogether broader treatment of the subject, which will classify the various kinds of partitioning possible in a perfectly general manner, without arbitrarily rejecting any.

Reasons are not wanting for undertaking an investigation of this sort.

Thus the fact that bodies which form crystals are capable of passing to a liquid state and back again to the crystallised condition *without breaking up into their constituents*, and the evidence we often have of the survival in the liquid of some portion of the symmetry of arrangement of parts prevailing in the solid, *notably in the cases of those bodies which rotate the plane of polarisation*, lead us to conclude that crystallised matter can be broken up into particles or units which are all alike, and each of which has parts or properties that have some definite arrangement relatively to one another.[2]

In some cases there is evidence of the survival in the dissolved crystal of two kinds of arrangement which are enantiomorphous, *e.g.* racemic compounds can mechanically or otherwise be shown to be composed of two isomers which are respectively right handed and left handed, but otherwise alike.

In the light of such facts as these the subject appears to be interesting, and likely to prove at least suggestive; the remainder of this paper is, therefore, devoted to an attempt to indicate broadly the lines on which it may be dealt with.

The symmetrical partitioning of homogeneous structures.

The existence of a homogeneous structure whose stability is such that it withstands internal or external forces, implies the existence of ties or bonds of some sort which keep it together, and preserve, or continually

[1] There does not indeed appear to be any evidence that the divisions of Fedorow's classification are at all traceable by the experimental facts at present known to us regarding crystals.

[2] This is true, whether there is any such thing as a crystal molecule distinct from a chemical molecule or not. There does not, it may be remarked, appear to be any adequate evidence of such a distinction.

restore its form, and the arrangement of these ties will conform to the definition of homogeneity. And in the case of a structure identical with its own mirror-image, the system they form will also possess the latter property.

Any *uniformly applied* disintegrating force will, as a consequence of the symmetry, break the ties, whatever they may be, in a uniform manner, so that the loosing of any given tie will be accompanied by the loosing of all ties similar to it throughout the structure; and if the disintegration leaves some ties intact, these also will be such as were similarly placed in the undissolved structure, *i.e.* the survival of any given tie will involve the survival of all ties similar to it in nature and situation. The application of a uniformly applied disintegrating force will not, therefore, produce the kind of partitioning above referred to, which is incompatible with the coincident-movements (Deckbewegungen)[1] of the structure.[2]

1. If the breaking of the ties does not bring about the absolute fluidity of any portions of the structure, but merely its separation into parts of relatively small magnitude, whose united bulk is that of the space originally occupied by the structure,[3] the latter will come to consist of a collection of fragments, either of one kind only, or of a definite number and variety of different kinds, continually repeated throughout space, and *of such form or forms as will, when properly fitted together, fill space without interstices.*

2. If, however, any parts of the structure become absolutely fluid or are vacuous, while other parts remain rigid, *i.e.* contain undissolved ties, the effect of the uniform loosing of some of the ties accompanied by disturbance will be to reduce the mass to a collection of rigid fragments, either all of the same pattern, or of a limited number of patterns, but not capable, as in the former case, of completely filling space; and they will be interspersed through the structureless fluid, that is if such a fluid, and not a vacuum, occupied in the dissolving structure the rest of space.[4]

Now if we confine our attention to simple structures only, *i.e.* to those whose ultimate fragments or particles, when liquefaction ensues, are all

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[1] See Note 3, p. 125. [2] See page 125.

[3] Expansion or contraction of the parts of the structure is neglected.

[4] If the ideas generally held respecting the nature of matter are substantially correct, this, and not the previous alternative case, will be that of actual partially liquefied homogeneous matter, *i.e.* of liquefied crystals the ultimate parts of which retain some kind of stable structure. Cases in which the fragments are not all of the same pattern are probably furnished by crystals containing "water of crystallisation," and by double salts.

similar,[1] we easily see that although the situation of the boundaries of these fragments is, in the case of any given type of homogeneous structure, quite indeterminate so long as the precise nature of the structure is unknown, we are able to range the infinite number of ways in which the given type is divisible symmetrically into similar fragments in certain distinct classes; and this applies whichever of the two alternative kinds of disintegration above defined obtains.

For in the case of each type all the infinite number of possible ways in which such a subdivision can take place can be classed in groups *according to the coincidence-movements (Deckbewegungen) found surviving in each of the isolated similar fragments or parts of the disintegrated assemblage.* And taking into account the possession by some of the structures of the additional property of identity with their own mirror-images, we may further distinguish cases in which each fragment is identical with its own mirror-image from cases in which the fragments are enantiomorphs, and consequently half of them right handed and the other half left-handed.[2]

Thus, for example, if a certain type of homogeneous structure contains a single set[3] of digonal axes of rotation, and a single set of trigonal axes of rotation, we can discriminate cases in which each fragment has a digonal axis and no trigonal axis from those in which there is a trigonal and no digonal axis, and both these again from those in which the fragment when isolated has no axis at all.

As to cases where there is identity with the mirror-image. If a type of homogeneous structure contains either centres of symmetry (inversion centres), or planes of symmetry, on the two sides of which parts enantiomorphically related are *directly opposite*, or centres about which parts thus related are arranged as in types 63c and 64c in my list,[4] *we can*

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[1] That is, either identically or enantiomorphically similar. Comp. cases of racemic compounds referred to above, p. 129.

[2] Cases are conceivable in which the enantiomorphic property of fragments is manifested only when they are considered with respect to the unbroken structure; they may themselves, considered alone, be destitute of this property. In other words, groupings which are identical with their own mirror-image, and all identically alike, may occupy two different sets of enantiomorphically similar situations in a structure. Indeed, the groupings which survive in the liquid state may, when considered alone, apart from the structure, have *any additional elements of symmetry which are compatible with those which they already possess as parts of the structure.*

[3] Axes are of the same set when their relation to the entire system of axes found in the structure is the same, *and that whether they can be brought to coincidence or not.*

[4] See *Zeitschr. für Kryst.* XXIII. p. 59.

have either kind of fragment produced by disintegration, that which is identical with its own mirror-image, or that which occurs always in two sorts, a right handed and a left handed. If, however, neither of the elements of symmetry just referred to is present, but the enantiomorphic correspondence of parts is solely due to the existence of those planes of symmetry (Gleitebenen) on the two sides of which related portions are *not directly opposite, the existence of finite fragments which as they lie in the structure are identical with their own mirror-image is precluded.*[1]

For if a portion A on one side of such a plane were joined in the same fragment with an enantiomorphically similar portion A′ situated on the other side of the plane, the existence of the translation of A requisite to bring it opposite to A′ would necessitate the existence of a similar translation in the *same direction and similarly related to the structure* of A′, which would therefore bring the latter opposite to a portion identical with A in form but not in position, and this third portion *must therefore, for the sake of symmetry, also form part of the same fragment.*

Consequently, unless an infinite chain of enantiomorphically related portions A, A′, &c. is found in the same fragment, no two such can in the last mentioned case be united *without impairing the symmetry of the structure*;[2] and, failing union of this kind, no fragment identical with its own mirror-image can be formed.

It is possible to state the method by which the classification referred to is to be accomplished in what is perhaps a conciser and plainer way.

In another place I have defined singular point-systems as those whose points consist of fewer points, and these in more symmetrical situations than are occupied by the other point-systems of a homogeneous structure.[3] *The different types of partitioning can be distinguished according to the nature of the central or of some most symmetrically placed point in one of the similar fragments, each different kind of singular point found in any given type of homogeneous structure forming the central or most symmetrically placed point of a distinct type of fragment, and there being in addition to the types thus distinguishable one other type of fragment in each case, that which has no point in it which the nature of the type of structure requires shall be more symmetrically situated than the rest.*[4]

[1] They may, however, considered apart from the structure, possess the property as a special peculiarity not derived from it. Comp. note 2, p. 131.

[2] Comp. *Zeitschr. für Kryst.* XXV. p. 88.

[3] *Zeitschr. für Kryst.* XXIII. p. 60.

[4] The least symmetrical type of all (hemipinakoidal-anorthic), as it possesses no singular points, presents but one type of partitioning for simple structures, *i.e.* for structures whose ultimate fragments are all similar.

The problem of finding the different types of partitioning possible resolves itself therefore into the problem of finding the different kinds of singular points present in each type of homogeneous structure.

The solution of the latter, as I have shown in the paper already referred to, depends on ascertaining precisely certain features of each type of structure, viz. :—

1. The different sets[1] of axes of rotation present.
2. The centres of symmetry.
3. The planes of symmetry which have the enantiomorphically related points directly opposite on their two sides.
4. The symmetrically placed planes with accompanying centres, such as those of the two types of structure identical with their own mirror-images, which have no centres of symmetry or planes of symmetry.[2]
5. The points and lines of intersection of these various elements of symmetry.

The table given below shows the result of applying the method of classification described to a few of the types of homogeneous structure belonging to the regular or cubic system; but before passing to this it may be helpful to state some conclusions as to the general features of the similar fragments produced by symmetrical partitioning.

The fact that no translation (Schiebung) or screw movement (Schraubung) can bring a fragment to coincidence with itself, shows that the only coincidence movements (Deckbewegungen) with which we have to deal are *rotations* of the unbroken structure.[3]

No fragment can, it is evident, have more than one axis of rotation *with the same direction;* and if it possesses more than one, inclined one to another, all such axes must intersect in a single point.

If a fragment possesses a digonal axis of rotation and no other, it will contain two identically similar points of every kind found in it, except those lying on the axis.

If a trigonal axis and no other, 3, except those lying on the axis.
tetragonal ,, ,, 4, ,, ,,
hexagonal ,, ,, 6, ,, ,,

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[1] See note 3, p. 131.

[2] There are some such planes in other types of structure besides the two 63c and 64c here referred to, which form a group by themselves. Comp. *Zeitschr.* XXIII. 59, XXV. p. 90.

[3] A fragment may, as we have intimated, have an axis or axes not found in the unbroken structure, but this is outside our province here, as we are not making a classification based on individual peculiarities of the fragments, but one based on the general features of the different types.

If two axes of rotation which are *not* both digonal axes intersect, it is evident that other similar axes must also pass through the point of intersection, the positions of which are discovered by carrying out movements about the two given ones; but the number of identical points involved does not equal the product of the co-efficients of all the intersecting axes. Thus the centre of a "24 punkter" of Sohncke is the point of intersection of six digonal, four trigonal and three tetragonal axes.

For each set[1] of axes of rotation in a homogeneous structure there will be at least one distinct corresponding group or type of varieties of partitioning, whose similar fragments possess such an axis. Also at least one distinct group for each different type of intersection of two or more axes, if there be any intersections, and at least one besides these of cases where the fragments possess no axes.

As regards those cases where the structure is identical with its own mirror-image, a plane of symmetry of a fragment, or any plane through its centre of symmetry, if it have one, will divide the fragment into two similar parts. If the fragment has an axis it also must evidently be central.

In no case can the fragment taken alone possess a plane of symmetry on the opposite sides of which corresponding points are not directly opposite (*i.e.* no Gleitebene), because such a property would, as already explained,[2] require the fragment to be infinite in one direction.

If an axis of a homogeneous structure lies in a plane of symmetry, the halves of the space units lying around the axis have contact with those of the same hand in this line only. It follows that when the fragments of the structure are such that this axis survives in them, they must, in order to be continuous *in substance*, also possess the plane of symmetry.

Summary.

The above investigation shows:—

1. The nature of homogeneity of structure, and the properties which distinguish it from structureless homogeneity. The new definition of a homogeneous structure recently put forward by the author in Groth's *Zeitschrift* is given.

2. A method of realising in a concrete form, and with great generality, the kind of repetition in space which constitutes homogeneity of

[1] See Note 3, p. 131.

[2] See above, p. 132.

structure, the models employed for this purpose each consisting of a number of similar plaster hands appropriately arranged in space.

The total number of types of arrangement, all of which can be represented in this way, is 230, this being the number of typical point systems described by Fedorow and Schönflies, derived by their extension of Sohncke's methods. The various types of homogeneous structure, like the corresponding point-systems, all fall into the 32 classes of crystal symmetry.

3. What property common to all homogeneous structures whatever most nearly corresponds to Thomson and Tait's definition of homogeneity.

4. Reasons for regarding as untenable the arguments put forward by Fedorow in support of his recent attempt to select from among the types of homogeneous structure those which are possible for crystals, and to determine the shapes of their ultimate units.

5. The possibility of so classifying all conceivable ways of symmetrically partitioning all the types of homogeneous structure as to avoid all reference to the nature of the cell-faces, whether plane or otherwise, and, in other respects also, be perfectly general. Some reasons for undertaking this classification, notwithstanding its complexity, are given, the chief one being the relation of symmetrical partitioning to some stereo-chemical and other experimental facts.

FRAGMENT OF A TABLE OF THE VARIOUS KINDS OF SYMMETRICAL SINGLE PARTITIONING WHICH CAN BE MADE OF THE TYPES OF HOMOGENEOUS STRUCTURE.

Type partitioned.	No. of Variety.	Elements of Symmetry of the Homogeneous Structure which survive in a Cell or Element of the Partitioning.
1	(1)	A trigonal axis
,,	(2)	None
$1a_1$	(1)	A trigonal axis and a centre of symmetry
,,	(2)	A trigonal axis only (the fragments are enantiomorphs)
,,	(3)	None (fragments enantiomorphs)
2	(1)	A trigonal axis
,,	(2)	A digonal axis
,,	(3)	None
$2a_1$	(1)	A trigonal axis and a centre of symmetry
,,	(2)	A trigonal axis only (fragments enantiomorphs)
,,	(3)	A digonal axis ,, ,,
,,	(4)	None ,, ,,
$2b_1$	(1)	A trigonal axis only ,, ,,
,,	(2)	A digonal axis ,, ,,
,,	(3)	None ,, ,,
3 or 4	(1)	A trigonal axis and a digonal axis
,,	(2)	A trigonal axis only
,,	(3)	A digonal axis only
,,	(4)	None

FRAGMENT OF A TABLE OF THE VARIOUS KINDS OF SYMMETRICAL SINGLE PARTITIONING WHICH CAN BE MADE OF THE TYPES OF HOMOGENEOUS STRUCTURE—*Continued.*

Type partitioned.	No. of Variety.	Elements of Symmetry of the Homogeneous Structure which survive in a Cell or Element of the Partitioning.
5	(1)	A trigonal axis and a digonal axis
,,	(2)	A trigonal axis only
,,	(3)	A digonal axis only, of the kind which intersects a trigonal in the unbroken structure
,,	(4)	A digonal axis of the other kind
,,	(5)	None
$5a_1$	(1)	A trigonal axis and a centre of symmetry
,,	(2)	A trigonal axis and a digonal axis (fragments enantiomorphs)
	(3)	A trigonal axis only (fragments enantiomorphs)
	(4)	A digonal axis only, of the kind which intersects a trigonal in the unbroken structure (fragments enantiomorphs)
,,	(5)	A digonal axis of the other kind (fragments enantiomorphs)
,,	(6)	None (fragments enantiomorphs)
6	(1)	Four trigonal and three digonal axes
,,	(2)	A trigonal axis only
,,	(3)	A digonal axis only
,,	(4)	None
$6a_1$	(1)	Four trigonal axes, three digonal axes, and a centre of symmetry, with accompanying three planes of symmetry
,,	(2)	A trigonal axis only (fragments enantiomorphs)
,,	(3)	A digonal axis and a plane of symmetry
,,	(4)	None (fragments enantiomorphs)
$6a_2$	(1)	Four trigonal and three digonal axes (fragments enantiomorphs)
,,	(2)	A trigonal axis and a centre of symmetry
,,	(3)	A trigonal axis only (fragments enantiomorphs)
,,	(4)	A digonal axis only ,, ,,
,,	(5)	None ,, ,,
$6b_1$	(1)	Four trigonal axes, three digonal axes, and six similar planes of symmetry
,,	(2)	A trigonal axis and a plane of symmetry
,,	(3)	A digonal axis only (fragments enantiomorphs)
,,	(4)	None ,, ,,
$6b_2$	(1)	Four trigonal and three digonal axes (fragments enantiomorphs)
,,	(2)	A trigonal axis only (fragments enantiomorphs
,,	(3)	A digonal axis only ,, ,,
,,	(4)	None ,, ,,
		&c. &c.

On the Humite Series.

By Professor W. J. Lewis, M.A.

[Read April 14th, 1896.]

THE humite series has formed one of the most interesting problems to mineralogists ever since Scacchi established the three types. I may, perhaps, recall that he found the crystals to be divisible into three classes, all capable of representation by reference to a common parametral plane and three zone-axes at right angles to one another. But the three classes differ in the following respects:—(1) Each has a peculiar set of faces, and, with the exception of the pinakoids and the actual or theoretical prisms, few of the forms coincide in different types. (2) Whilst all the faces on crystals of one class can be easily represented by quite simple indices, such as (111) (123) (103) by a judicious selection of one of its faces as parametral plane, the faces on crystals of the remaining two classes give for the same parameters very high and complicated indices. For the sake of simplicity of indices a different parametral plane has therefore to be assumed for each class. (3) Whilst in one class, that now specially denoted as humite, the faces are arranged about the axes so as to conform to the holohedral forms of the rhombic system, in the remaining two classes the faces are developed in sets of four tautozonal planes in the manner characteristic of the oblique system. This latter character so impressed Miller, whose material was limited, that he has described the mineral as oblique. Miller's crystals were undoubtedly of the kind now termed clinohumite. His determination, apparently simultaneous with Scacchi's work, is very accurate, and the commonest twin law of the class is given in a very precise manner.

The next important contribution to our knowledge was vom Rath's classical memoir published in 1871 (*Pogg. Ann. Erg. Bd.* V.). He confirmed Scacchi's results, and gave a very exhaustive description of the twins of the different classes, many of which had hitherto escaped notice. Referring the crystals to the same axes, he gave the following parameters, which have been but slightly modified since,

	a	b	c	$= m\gamma$
Chondrodite ...	1·08028	: 1 :	3·14379	$= 5 \times$ ·62876
Humite... ...	1·08028	: 1 :	4·4013	$= 7 \times$ ·6288
Clinohumite ...	1·08028	: 1 :	5·65884	$= 9 \times$ ·62879

The faces present on crystals of the three varieties are now all capable of simple representation. Thus we have common prisms {110}, {120}, also a series of domes $i_1\{011\}$, $i_2\{012\}$, &c.

The faces of forms $e_1\{101\}$, $e_3\{103\}$, &c., which should form domes, are found in chondrodite and clinohumite to be frequently present in pairs of parallel faces only, or those inclined to one another are differently developed.

Again, we have zones common to all the varieties with forms $n_1\{111\}$, $n_3\{113\}$, &c., and $r_1\{121\}$, $r_3\{123\}$, $r_5\{125\}$, &c., which should constitute pyramids of eight faces. This is the case in humite. But in the other two varieties we have frequently only sets of four tautozonal faces, the characteristic form of the oblique system, and the pyramid, when eight faces with equal indices are present, is generally divisible into two sets of four tautozonal planes, owing to different development.

In 1876 M. DesCloizeaux showed that chondrodite and clinohumite both form polysynthetic twin-lamellæ parallel to (001), and that sections of such crystals parallel to the pinakoid $b(010)$ do not, between crossed nicols, extinguish the light in the lamellæ simultaneously or parallel to the base. In chondrodite the direction of extinction makes an angle with (001) of nearly 30°, and is nearly parallel and perpendicular to the important normal $e_5(105)$. In clinohumite the extinction of the lamellæ occurs in a direction inclined at $+11°$ to the vertical axis. This had already been established by Prof. E. S. Dana for chondrodite from Brewster, and was at a later date confirmed by him for clinohumite. At the same time M. DesCloizeaux showed that humite has no twin lamellæ parallel to (001), and that the extinction in sections parallel to (010) is parallel to the face (001). Hence humite is rhombic, whilst chondrodite and clinohumite have to be relegated to the oblique system. It has not, however, been found possible to find variations in the angles between the base and faces, such as $\pm e_3$ $\pm n_3$, which have like indices but lie on opposite sides of the axis ZZ'. Hence the angle between the axes of X and Z has to be regarded as 90°; and Prof. Dana says that careful examination of chondrodite crystals has convinced him that the angle XOZ cannot differ by 1′ from 90°.

In 1894 Prof. Penfield showed by a series of careful analyses that if the water be taken as hydroxyl (HO) replacing fluorine, the three varieties have the following composition :—

Chondrodite	...	...	$Mg_3[Mg(F,OH)]_2(SiO_4)_2$
Humite	...	...	$Mg_5[Mg(F,OH)]_2(SiO_4)_3$
Clinohumite	...	...	$Mg_7[Mg(F,OH)]_2(SiO_4)_4$

He also points out that the number of atoms of Mg in each gives exactly the multiple of $\gamma = \cdot 6288$ required for the parameter c. This being the rule he then indicates the possibility of an extension of the series $Mg_{2x-1}[Mg(F,OH)]_2(SiO_4)_x$ with parameters $a : b : (2x+1)\ \gamma$, and also that the lower term is probably $Mg[Mg(F,OH)]_2SiO_4$ with parameters

$$1 \cdot 08028 : 1 : 1 \cdot 88628.$$

In passing from one member to the next one in the above series the chemical change consists in the addition of a molcule of forsterite Mg_2SiO_4 or olivine $(Mg,Fe)_2SiO_4$, and the addition of 2γ to the parameter c.

Now Prof. Sjögren[1] (*Bulletin of the Geol. Inst. of Upsala* II.) has recently announced the discovery of prolectite with the parameters just given, *i.e.* with $c = 3\gamma$. The amount of material at his disposal has not enabled him to analyse the substance; but there is a strong presumption that its composition will accord with that suggested by the rule of the series.

Now the comparison with olivine, though frequently made, has not brought out the relation between it and the members of the above series with much precision. This is to some extent due to the recent adoption of the parameters of Kokscharow instead of those of Naumann and Miller. If we take the representation given in Miller's edition of *Phillips' Mineralogy*, 1852, we have parameters

$$a : b : c = 1 \cdot 0733 : 1 : 2 \times \cdot 6297,$$

where a and b are almost identically those of the humite series, and the multiple of γ (namely 2) is the number of atoms of Mg. The parameters of forsterite differ very slightly from those of olivine.

To carry the inquiry to the lowest possible step, we must go to enstatite and hypersthene $(Mg,Fe)SiO_3$. Unfortunately the crystals of these substances so far available leave much to be desired. The divergence from the parameters $a : b : \gamma$ is much greater than those which exist in the preceding minerals. The prisms {110}, {120} have angles differing greatly from those in the same forms of olivine and the humites, and the acute angle of {110} occupies the position of the obtuse one in the humites. But if we consider the zone [100, 001] —a pseudo-hexagonal

[1] See p. 161 below.

zone in all the minerals—we find the ratio of $a : \gamma = 1{\cdot}0685 : {\cdot}62886$; a very close approximation to that required by the series. The divergence from the rule of the series is then thrown on the parameter b, which becomes 1·1013, when c is ·62886. The variation in the ratio $a : b$ is not surprising, seeing that there has been a change from an ortho- to a meta-silicate.

We may call attention to the remarkable fact that the twin-face in all the minerals, except clinohumite, is practically the same face, *i.e.* one making an angle of nearly 30° with $e(001)$, which meets the axes at distances a and γ, and has the indices (101), (102), (105), (107), in the different minerals.

In clinohumite the common law is twin-face $-e_3$ $(\bar{1}03)$, *i.e.* a face at nearly 90° to (109).

The examination of prolectite is as yet too incomplete, owing to lack of material, for us to know whether it will correspond to or deviate from the common rules of twinning.

Again, as to habit, we have the curious fact that all the minerals have a marked inequality in the development of like faces, so as frequently to give the appearance of oblique crystals. The extinctions and the other optic phenomena have been very carefully determined by several observers of the greatest skill. We can, therefore, hardly expect that future investigations will relegate the whole series to the oblique system. At the same time such a result would harmonise with the close relation which exists between enstatite and pyroxene.

Another common feature is the great predominance of the forms lying in the zones [010], $[1\bar{1}0]$ $[2\bar{1}0]$ *i.e.* faces such as $e(101)$, $e_3(103)$ $n_1(111)$, $n_3(113)$, $r_3(123)$ $r_1(121)$, &c. In these zones the faces are never the same, for being represented by the same indices, they occupy different positions owing to c being a different multiple of γ. It may not be amiss to point out that the minerals closely approximate in density, hardness and fusibility. If V represents the molecular volume, M the weight of the atoms in the chemical molecule, and d the density, and hence $V = \frac{M}{d}$. Then we have—

For Olivine ...	...	$V_2 = 44 = 2 \times 22$
Chondrodite	...	$V_5 = 105{\cdot}6 = 5 \times 21{\cdot}1$
Humite ...	...	$V_7 = 150 = 7 \times 21{\cdot}4$
Clinohumite	...	$V_9 = 182{\cdot}1 = 9 \times 20{\cdot}2$
Enstatite	...	$V_1 = 32{\cdot}8 = \frac{3}{2} \times 21{\cdot}9$

The attempt to get topical axes, as suggested by Herr Muthmann, clearly gives no new relation.

Notes on a biotite-cyanite-cordierite-rock from the Upper Satlej Valley, N.W. Himalayas.

By Lieut.-General C. A. McMahon, V.P.G.S.

[Read June 23rd, 1896.]

SOME years ago I found in the bed of the Satlej at Wangtu, in the N.W. Himalayas, about 80 miles, as the crow flies, north-east of Simla, a boulder of the rock described in the following pages. It is composed of biotite, cyanite and cordierite, with apatite and rutile as accessory minerals.

The specimen has a specific gravity of 2·92. Its structure is holocrystalline, and its minerals show no trace of parallelism in their orientation. It is, I think, a product of contact metamorphism.

I have not come across the above rock *in situ*, but the Upper Satlej at and above Wangtu is a region of intense granitic eruption and cyanite and other contact-metamorphic minerals, are to be found there in great abundance.[1]

Thin slices having been studied under the microscope, the following remarks are offered on the rock and its component minerals.

Biotite.

The biotite is quite black when viewed macroscopically, but in thin slices and in transmitted light it exhibits strong pleochroism, (c) being dark green, (b) green, and (a) greenish yellow. The scheme of absorption is $a > b > c$.

The whole of the colouring matter and the bases are removed from the biotite on heating in nitric acid, and the solution thus obtained reacts for iron, magnesia and lime. The residue consists of amorphous silica which is completely soluble in a solution of caustic potash. The interesting point is that this amorphous silica, after yielding its bases to hot nitric acid, preserves the cohesion, the hexagonal shape, and the pronounced lamination of biotite. Whilst completely retaining the

[1] Some fine specimens of cyanite found in granitoid gneiss a mile or two above Wangtu were exhibited when the paper was read.

characteristic form and lamination of biotite, however, it loses the whole of the optical properties of that mineral and acquires those of amorphous silica. After treatment with acid it has no action on polarised light, and its refraction falls from that proper to biotite, to that proper to amorphous silica. The indices of refraction for biotite are n_g 1·606, n_p 1·562; but I find from actual observation that the refractive index of the siliceous residue of the biotite is higher than 1·374, and lower than 1·437; the mean of these figures being 1·405.

The above facts are, I think, suggestive. They not only show that the optical properties of biotite depend on the bases present—a conclusion arrived at by other observers in the case of some other minerals—but they also appear to throw some light on the constitution of the biotite molecule, and suggest that the bases are linked to the silica in such a way that their atoms may be replaced by water, or its constituents, without the molecule being broken up. That the loss of the bases did not break down the molecule, seems to me clear from the fact that though the optical and other physical properties of biotite were changed, the hydrated siliceous residue retained the form of biotite as perfectly as ever. Had the biotite molecule been broken up, we should have got pulverulent or flocculent silica, but the form of biotite would, it seems to me, have been lost.

Biotite is now so fully recognised as a product of contact metamorphism that no remarks on this subject seem necessary. I would only say, in passing, that I have seen several interesting cases in the Satlej Valley of the production of biotite by the contact action of granite on basic rocks of igneous origin. I place on the table a hand specimen in illustration of this statement. One half of the specimen consists of brown biotite, and the other half of a fine-grained diorite or epidiorite.

Cyanite.

The cyanite seen in the Wangtu rock is white in reflected, and colourless in transmitted light. It is in blade-like prisms with irregular terminations and somewhat corroded sides. The longitudinal and transverse cleavages are usually well developed. Sometimes the former become very pronounced and the mineral passes into sillimanite. Sometimes the cyanite frays out into sillimanite needles, or needles of this mineral are seen in its immediate vicinity; the passage of the one mineral into the other is never, however, absolutely complete, for though it loses its oblique and puts on straight extinction, the major axis remains at right angles to the length of the prism instead of becoming parallel to it, which is the normal position for sillimanite.

Cyanite is, as is now well known, a recognised product of contact metamorphism arising from the vicinity of granite, and its abundance in the zone of contact-metamorphism in the south-eastern Highlands of Scotland, has been described by Mr. G. Barrow in his able paper published in the forty-ninth volume of the *Quarterly Journal of the Geological Society* (p. 330).

Cordierite.

Cordierite in this rock was the last mineral to crystallise. It is uniformly allotriomorphic and it does not present any suggestion of crystallographic form or of cleavage. Its refractive index I found to be above 1·538 and below 1·547, which would do for quartz, andesine, oligoclase or cordierite. Its double refraction did not serve to distinguish it, and in specific gravity the above minerals come near each other. Its behaviour in converging polarised light showed that it was not quartz. All doubt, however, as to the identification of the mineral in the Wangtu rock has been removed by Mr. G. T. Prior, F.G.S., Mineralogical Department of the British Museum, to whom I am much indebted for the determination of this mineral. He succeeded in isolating and analysing minute fragments, which yielded magnesia and the other constituents of cordierite, and exhibited a delicate but appreciable dichroism under the microscope.

Accessory Minerals.

The specimen contains apatite, mostly in granules, though nests of micro-prisms occur here and there. The granules are soluble in nitric acid, and the solution reacts for phosphoric acid with ammonium molybdate, and for lime with sulphuric acid. The optical properties of the granules are those of apatite.

Numerous small crystals of rutile are also to be found in very thin slices. They occur most frequently in the biotite; less so in the cordierite, and more rarely in the cyanite. They are sausage-shaped, or in stumpy crystals with rounded angles. I have only observed one or two cases in which the rutile assumes the needle shape. Most of the crystals of rutile polarise brilliantly.

No magnetite is to be seen, but now and then there is a little ferric oxide stain.

General Remarks.

One of the questions which arise in connection with this rock is its probable origin. What kind of rock was it before it was metamorphosed?

A cyanite-gneiss has been described by Mr. Barrow, in his interesting

paper before referred to, the crystalline structure of which the author attributes to the contact action of granite, intensified by the great depth below the surface at which that action took place. "The sedimentary origin," the author writes, "of the group of rocks last described" [those of the staurolite zone] "will probably be admitted without question, but in the case of the more highly altered rocks" [this apparently includes the cyanite zone] "it is not so clear." The author appears, however, to incline to the view[1] that the rocks of the sillimanite and cyanite zones are also of sedimentary origin.

There are some points of resemblance and some points of difference between Mr. Barrow's cyanite-bearing gneisses and the rock above described. The former are foliated but the latter possesses a perfect granitic structure. The Scotch rocks contain muscovite, felspar, free quartz, garnet, chlorite, iron ores and tourmaline, none of which are present in the Wangtu rock, whilst the latter contains cordierite, apatite and rutile, absent from the Scotch rocks. Biotite and cyanite are common to and abundant in both.

The high specific gravity of the Wangtu rocks, coupled with the absence of free silica, and the presence of apatite, are points which seem to bear on the question of origin. Apatite is characteristic of some rocks of igneous origin, and free silica is a characteristic constituent of aqueous sediments.

I framed an estimate by taking the minerals contained in the Wangtu specimen in such proportions as would give a rock with a sp. gr. of 2·92, and calculated the chemical contents from the formulæ of these minerals. The result came near the composition of augitite. Until the Wangtu rock is found *in situ*, however, nothing definite can be affirmed regarding it, but I think the probabilities of the case are in favour of its being a contact-metamorphic rock of original igneous origin.

Mr. Barrow, in the paper already referred to, called attention to the fact recorded by Dana in the last edition of the *System of Mineralogy*, that cyanite is, at a temperature of 1320°-1380° C., converted into sillimanite. I have shown that the commencement of this change had been set up in the Wangtu rock. We may, therefore assume that the latter was heated until it reached a temperature of about 1320° C. If so, the heat to which the rock was raised was sufficiently high to have completely fused a basic rock of igneous origin. The melting point of diabase is said[2] to be between 1100° C. and 1170° C., and that of ordinary

[1] *l. c.* p. 351.

[2] Lord Kelvin quoting Carl Barus, *Nature*, Vol. LI. p. 439.

basalt 815° C.[1] The minerals of which the Wangtu rock is composed therefore, probably resulted from the fusion of the original rock from which it was derived, and from the rearrangement of its component silica and bases.

Looking at the rock from this point of view, its microscopical examination presents some points of interest. The first stage in the formation of the metamorphosed rock seems to have been the crystallising out of the contact minerals, and subsequently when the heat reached its maximum the last formed and more acid mineral, cordierite, began to corrode, and eat into the more basic minerals.

This corrosion and partial re-solution may be traced in the illustration (Plate III. Figs. 1-5). The action of the cordierite on the biotite is rather remarkable, the majority of the biotite crystals being fringed with tags of half dissolved mica. A question naturally arises whether these tags are portions of the biotite in process of re-solution, or whether they represent a re-deposition of mineral matter previously held in solution in the cordierite. I do not think the latter is the true explanation for the newly deposited mineral—especially if it were biotite, deposited on biotite—would surely have been deposited in a layer on the previously formed mineral and not in the form of a fringe of tags depending from the edges of the biotite leaves. Moreover the faces of these leaves often exhibit a series of vermicular marks resembling microscopic worm burrows, which seem to be due to the corrosive action of the comparatively acid mineral on the basic biotite suspended in it.

These tags have a high refractive index, the major axis is at right angles to their length, many of them are distinctly dichroic, and biotite is the only mineral they are attached to.

The study of this, and other crystalline rocks, has led me to the conclusion that a double action may be set up in such rocks when subjected to thermal action under pressure, and more or less completely fused. There is first a constructive action in the crystallising out of minerals, and this may in some cases be succeeded by a destructive action in the corrosion, and partial re-solution, of some or all of these minerals, by the comparatively acid mineral that plays the rôle of the base or residuum. A change of temperature, or an alteration in the melting point due to relief of pressure, seems sufficient in some cases to bring this about. This double action is often to be seen in granites.

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[1] Professor Sollas relying on Dr. Joly, *Nature*, Vol. LI. p. 534.

NOTES AND COMMENTS.

THE Society has lost one of its Corresponding Members in the person of Professor G. A. Daubrée, the Director of the École des Mines, who died on the 20th of May, 1896, at the age of 82. Among his numerous publications on experimental geology and the allied subjects were many of extreme importance to the Mineralogist, especially in relation to the origin of minerals. In fact, the desire to explore the suggestive problems of mineral genesis seems to have inspired not only those remarkable investigations which are included in his *Etudes synthétiques de Geologie Experimentale* and in his well-known treatise on Underground Waters, but also his lively interest in Meteorites. The death of this eminent man is as great a loss to Mineralogy as to Geology.

We have also to record the following deaths which have taken place since the last issue of this Magazine :—On September 22nd, 1895, died Dr. Friedrich Nies, an ardent Mineralogist, who was Secretary of the Geological Association of the Upper Rhineland; and on October 10th, 1895, in his 49th year, Dr. Albert E. Foote, the well-known mineral collector and dealer, of Philadelphia, through whose enterprise and energy many new and important minerals were secured for the Museums of the United States and of Europe.

Among recent appointments are to be mentioned that of Dr. O. Mügge, of Münster, to the Professorship of Geology at Königsberg, of Dr. Karl Busz to the Chair at Münster vacated by him, and of Mr. H. A. Miers to the Professorship of Mineralogy at Oxford, in succession to Professor N. Story-Maskelyne, retired.

The following is the subject offered for competition by the Fürstl. Jablonowskische Gesellschaft, in Leipzig, for a prize of £50, to be awarded in 1899 :—

An experimental investigation upon the problem as to what are the

conditions which determine the development of the various simple forms, or their mutual combinations, in crystals; regard being also had to the literature which bears upon the subject. It is desired that the investigation shall take into account such subtances as would yield results which might be extended to natural minerals.

The Memoir is to be written anonymously in German, Latin, or French, enclosed in a sealed cover with motto, and must be sent before the 30th of November, 1899, to the Secretary of the Society.

OBITUARY.

Alexander Henry Green, F.R.S.

THE Mineralogical Society has lost a prominent Member by the death of Professor Green on the 19th of August, 1896. He was born in 1832; having graduated as 5th Wrangler at Cambridge in 1855, he was in 1861 appointed an Assistant Geologist on the Geological Survey; in 1875 he was appointed Professor of Geology at the Yorkshire College of Science at Leeds, and was largely instrumental in achieving the success of that institution in its early days.

In 1888 he was elected to the Chair of Geology at Oxford. Though a Geologist by profession, he always took an active interest in Mineralogy; he was almost an original member of this Society, and was a member of Council on various occasions, beginning with the year 1879. He was gifted with a singularly clear and effective style which invested his words, whether spoken or written, with a great charm; of this his book on Physical Geology is a conspicuous example.

This power of lucid exposition rendered him a most attractive teacher, while his hearty and genial character endeared him to all those who enjoyed his friendship.

REVIEWS.

An Introduction to the Study of Rocks. By L. Fletcher, Mineral Department, British Museum (Natural History). There are many ways in which a collection of rocks can be arranged, each carrying its own useful lesson. The chief types of rocks may be selected and so placed as to indicate their mutual relations as constituents of the earth's crust ; or they may be made to illustrate the various ages of the rocks, and the progressive changes that the earth went through during its growth ; or again the different products of each locality may be placed in close proximity so as to illustrate the mineral resources, age and character of the rocks at each locality ; or again, the collection may embrace the chief sorts of rocks and endeavour to give the history of each important class. But the chief interest of rocks to the mineralogist is as the habitat of minerals, and we suppose that this is the purpose which Mr. Fletcher had in view in writing this guide and in arranging the collection to which it refers.

But even with this comparatively limited object in view, the mineralogist no less than the petrologist finds his task a very difficult one, for no one character can be taken alone, and almost every set of characters when taken as a basis leads to one or more absurdities. Rocks are mineral aggregates and can be broken up mechanically into one or more mineral species, usually in combination with more or less matter which, though really complex, cannot be thus physically resolved ; minerals and amorphous matter can be formed in several different ways so that rocks may have many different kinds of origin. On going to the rock-mass itself, it is found to be a complex entity ; the simple " petrical individual " is very rarely to be met with, and it becomes necessary to confine attention to small portions of the rock at a time, and to name these if necessary, although in doing so it is well to notice their relations to the rest of the rock-mass both in structure and composition. The list and explanation given in this introduction of the chief " lithical " characters to be looked for will be found to be a most useful and exhaustive one. The " petrical " or larger features have also been treated with adequate justice. Aided by the knowledge thus acquired we are now prepared to enter upon a classification, remembering always that " the knowledge of a fragment is

merely an aid to the knowledge of the whole," for "a single mass may consist of more than one kind of rock," although such are, as a rule, merely varieties of the main type. Although the age of the rock may be an important character in indicating a particular phase in the earth's history, its chief function is in producing alterations in the rock, often of such import that two rocks initially identical may become totally unlike each other, or rocks originally quite different may eventually result in the same, *e.g.* the serpentines.

In endeavouring to hit upon the best basis for a classification it is found that mode of origin is the most reliable guide to the mineralogist, as well as to the geologist and petrographer; with the aid of it we are able at once to divide the sediments or aggregate rocks from the igneous group, and although when we carry this method to its logical issue we are often compelled to place in widely separated divisions one or two rocks which to ordinary methods of research are identical, this is better than such grouping as that of crystalline schists, which includes igneous rocks with flow-structure, dynamically metamorphosed rocks, products of contact-metamorphism, and possibly others to which all or several of these methods have contributed.

The classification to be adopted chooses the following chief types round which others may be grouped; the grouping of the igneous rocks will be found to be in the main a chemical one, and not widely different from that generally in use amongst geologists:—granite, syenite (including felspathoid rocks), diorite, gabbro (also including felspathoid rocks), and dunite. As subdivisions of these types are treated porphyritic, "mero-crystalline" (including semi-crystalline and crypto-crystalline varieties), and glassy types; and these forms are again divided by their minuter mineralogical variations. Then we have the gneisses and crystalline schists, the tuffs, sandstones and clays, the limestones and marls, and finally the coals.

The work will be found very useful to the student of classification, as he will find many of the old facts put strongly and often in quite a new light. Many of the chief difficulties are gone into very thoroughly, while the whole book is a conscientious attempt to make very clear to the mineralogist the nature and characters of the habitats of those minerals of which the bulk of the earth's crust is built up. W. W. W.

C. F. Rammelsberg; *Handbuch der Mineralchemie.* Zweites Ergänzungsheft. Leipzig, 1895.

In this supplementary volume to the second edition of his invaluable

Handbook, the venerable Professor displays once more his marvellous industry, and brings together a critical summary of all the mineral analyses which have been published since the year 1886. As in the earlier volumes, the author confines himself to empirical formulæ, and dismisses, as too speculative for his handbook, the numerous recent attempts to establish structural formulæ for minerals. On the other hand, he adopts, for example in the arsenides, oxides, &c., such rational formulæ as seem to him most in accordance with the facts. With such compounds as the oxy-chlorides, the chlorine is not regarded as capable of replacing the oxygen, and similarly the radicle RCl or RCl_2 is assumed in the borates, carbonates, sulphates, phosphates and silicates.

In these matters the author confesses himself strongly conservative, and he entirely refuses to accept the newer views regarding the replacement of fluorine by hydroxyl in many so-called hydrated compounds.

Thus, in the case of topaz, he adheres to the formula $mAl_2SiO + nAl_2SiFl_{10}$, and regards the water as indicating incipient decomposition.

Like the previous volumes, the book is one which is an absolutely indispensable work of reference to every Mineralogist.

Ostwald's Klassiker der exakten Wissenschaften, No. 75. *Abhandlung über die Herleitung aller Krystallographischen Systeme mit ihren Unterabtheilungen aus einem einzigen Prinzipe, von Axel Gadolin, deutsch herausgegeben von* P. Groth.

This excellent series of annotated German translations of classical papers in the various sciences, is now enriched by Professor Groth's edition of Gadolin's masterpiece. In this highly original memoir the author, without knowledge of the previous investigations of Hessel and of Bravais, proved in the year 1867, by an extremely simple and elegant method, that if the law of rational indices be accepted, then only 32 classes of crystals are possible, distinguished from each other by their characteristic symmetry.

At the present time when these conclusions are generally based upon structural theories, it is very suitable that the proof which is independent of any speculations regarding structure should be recalled to the minds of students of this subject.

Professor Groth's brief notes and the historical sketch by which they are preceded are excellently adapted to make the subject intelligible; particular attention may be drawn to the note on Chap. III., where an explanation is given of the modern conception of "composite" or "alternating" symmetry.

Abstracts.

Geology of the Highwood Mountains of Montana (W. H. Weed and L. V. Pirsson, *Bull. Geol. Soc. Amer.* VI, pp. 389-122). The mountains of which an account is given in this paper form one of the detached groups to the east of the Rocky Mountain Cordilleras. They consist of the denuded remains of a group of volcanoes which were erupted through cretaceous strata.

A characteristic feature of the geologic structure is the enormous number of dykes which radiate outwards from a number of volcanic cores surrounded by tuffs and lava-flows.

The sedimentary strata consist of sandstone and clayey shales. In the lowest series, classed II as Kootanie, occurs the most important single coal seam in the state of Montana.

Most of the volcanic cores consist of granular rocks (syenite and a new type called shonkinite), showing that considerable denudation has taken place.

The chief interest of the paper centres in the description of the remarkable structure of the igneous mass known as Square Butte, which, although genetically and geologically part of the Highwoods, is geographically a distinct and separate elevation. Square Butte presents the appearance of a short but huge cylindrical mass of white rock resting upon a low broad truncated cone of dark rock. The result of the authors' observation seems to show that it is a laccolite which has been intruded in cretaceous sandstones. When intruded the mass was homogeneous, but while it was still in the liquid state a process of differentiation set in, the result of which was that the magnesia, lime and oxide of iron were concentrated in an outer zone to form on solidification a basic granular rock composed essentially of augite and orthoclase (shonkinite), while an inner nucleus richer in alumina, alkalies and silica was left to solidify as a sodalite-syenite.

A remarkable feature of the lower slopes of the mountain formed of the dark basic rock to which the authors give the name shonkinite, is the vast series of "hoodoos" or forest of monoliths into which this rock has been carved by erosion.

Both the syenite and the shonkinite exhibit a peculiar platy structure, which the authors consider to have been developed during the cooling of the mass, parallel to the form of the laccolitic cover which has been long since removed by denudation.

As regards the petrography of the two rocks, the shonkinite consists mainly of augite (about half the rock consists of this mineral) and orthoclase, but contains also the following accessory minerals: olivine, biotite, apatite, iron ore, albite, anorthoclase, sodalite, nepheline (?), cancrinite (?), and zeolites. The minerals lie unorientated, forming a holocrystalline, coarse-grained hypidiomorphic structure. In chemical composition it is closely related to certain Vogesites and minettes. It bears such a relation to augite-syenite as vogesite to hornblende-syenite.

Analysis of Shonkinite.

SiO_2	...	46·73
TiO_2	...	·78
Al_2O_3	...	10·05
Fe_2O_3	...	3·53
FeO	...	8·20
MnO	...	·28
MgO	..	9·68
CaO	...	13·22
Na_2O	...	1·81
K_2O	...	3·76
H_2O	...	1·24
P_2O_5	...	1·51
Cl	...	·18
		100·97
O = Cl	...	·04
		100·93

The light-coloured inner core of sodalite-syenite has previously been described by Lindgren and Melville (*Am. Jour. Sci.*, XIV, (1893), p. 386). It consists mainly of orthoclase, through which are scattered slender black hornblende (near arfvedsonite) prisms, and small grains of sodalite. The structure is rather coarsely granular, like the shonkinite. Accessory minerals are apatite, albite and analcite, nepheline and natrolite.

G. T. P.

A new basic orthoclase-bearing rock from Canada. To the increasing number of basic rocks rich in alkalies, and in alkali-felspars, Lawson has recently added new types of somewhat peculiar chemical and mineralogical composition (*Bull. No.* 12, *Dep. Geol. Univ. of Calif.* 1896). They are plutonic rocks forming a laccolitic intrusion some six miles in length among mica-schists of pre-Cambrian (Coutchiching) age at Poohbah Lake in the Province of Ontario. The author gives to these rocks the name malignite, and regards them as constituting a new rock-family. Three types are described. The first is nepheline-pyroxene-malignite, and consists of pyroxene, orthoclase, nepheline, apatite, biotite and sphene, in order of abundance. The pyroxene, making up nearly half the rock, is an ægirine-augite with green and yellow pleochroism and an extinction-angle $c\gamma = 59°$. The orthoclase, which is practically a pure potash-felspar, has been the latest product of crystallisation, and builds large crystal-plates enclosing the other minerals. The nepheline, partly altered by decomposition, occurs in idiomorphic crystals about $\frac{1}{2}$ mm. in diameter, or sometimes forms a micrographic intergrowth with the orthoclase, as in the borolanite described by Teall. The apatite makes up nearly 6 per cent. of the rock, occurring in stout prisms up to 3 mm. long. The chemical composition of the rock is shown in Column I., the most striking feature being the richness in alkalies and lime of so basic a rock. The silica is too low and the lime too high for a nepheline-syenite. The iron and magnesia are lower and the alkalies higher than in the shonkinites of Montana. The alumina is much lower and the magnesia and lime higher than in borolanite. The malignite resembles, however, pretty closely the Vesuvian lavas, and may be regarded as their plutonic equivalent.

	I.	II.	III.	IV.
SiO_2	47·85	51·88	48·86	51·38
TiO_2	—	0·33	—	0·12
Al_2O_3	13·24	14·13	17·40	15·88
Fe_2O_3	2·74	6·45	7·67	1·48
FeO	2·65	0·94	0·48	4·37
MgO	5·68	3.44	—	4·43
CaO	14·36	10·81	—	8·62
Na_2O	3·72	6·72	8·13	7·57
K_2O	5·25	4·57	2·81	4·20
H_2O	2·74	0·18	—	0·42
P_2O_5	2·42	0·96	—	0·98
	100·65	100·41		99·45
Sp. gr.	2·879	2·88	2·98	

The other two types do not contain nepheline. One is a garnet-pyroxene-malignite, differing structurally as well as mineralogically from the preceding. The orthoclase occurs in large tabular crystals 4 to 6 cm. in length, and has a microperthitic intergrowth of albite. The other minerals, forming a granular aggregate, are, in order of abundance, ægirine-augite, melanite-garnet, biotite, sphene and apatite. In chemical composition (II.) this rock has some resemblance to Brögger's laurvikite, but is poorer in silica and alumina and richer in ferric oxide and lime. A somewhat more basic variety of the rock differs in appearance owing to the felspars being much smaller in size. A partial analysis of this gave the result in Column III.

The third type is amphibole-malignite. This has also large crystals of microperthite, though not so large as before. Garnet is wanting, and the ægirine-augite is mostly replaced by an arfvedsonite-like hornblende, with parallel intergrowths of the two minerals. Biotite, sphene and apatite occur as before. This rock gave the analysis cited under IV. A. H.

A Picrite from Devonshire. K. Busz describes six eruptive rocks from the borders of Dartmoor. Most of these are diabases, but the most interesting is a picrite ("palæopicrite"), from Highweek near Newton Bushel (*Neues Jahrb. f. Min.* 1896, Vol. I. p. 57). The olivine, which is the dominant constituent, is in great part fresh, but shows the serpentine-change in various stages. Chlorite has also been produced near the contact of the olivine with biotite or felspar. Augite occurs usually in imperfect crystals of brownish violet colour in slices, with very feeble pleochroism.

SiO_2	40·12
Al_2O_3	7·76
Fe_2O_3	7·35
FeO	8·66
CaO	6·53
MgO	23·69
Na_2O	1·20
K_2O	0·53
H_2O	4·03
TiO_2	0·37
P_2O_5	0·18
FeS_2	0·20
Cl, CO_2, Cu ...	traces
	100·62

Enstatite and little flakes of biotite are also present, and a considerable amount of anorthite. Apatite needles are associated with the biotite, and magnetite is found chiefly as a secondary product with the serpentine. The rock has a specific gravity 2·988, and a composition given by the above figures. A. H.

The Triassic eruptive rocks of the Southern Tirol. We have already noticed (p. 114 of this volume) the first part of W. C. Brögger's *Eruptivgesteine des Kristianiagebietes.* The second instalment, since published, deals with the rocks of the long famous district of Predazzo and Monzoni, this digression being justified by the instructive parallel drawn between the Tirolese and the Norwegian rocks (*Vid. Selsk. Skrifter, Math.-Natur. Kl.* 1895, No. 7). After a historical survey of the subject, the author discusses from a chemical and mineralogical standpoint the well-known monzonites, insisting especially upon their classificatory position between the syenites and the diorites, as rocks in which both an alkali- and a lime-soda-felspar are essential constituents. He shows how, from this point of view, a number of rocks from various districts may be referred to the definite passage-group thus established.

The relation between the monzonites of Predazzo and Monzoni and the associated "pyroxenites," of more basic composition, is next considered. Dölter twenty years ago suggested the hypothesis that the two sets of rocks, so intimately bound up together, might have originated from one and the same magma, and Brögger shows how, in the light of modern theories of differentiation, this suggestion acquires great force. In his opinion the pyroxenites occur as marginal facies of the monzonites; and the resemblances and differences between the two are such as are found in other districts between rocks holding a like relationship. In some places there is a gradual transition from monzonite to pyroxenite; elsewhere the boundary is a sharp one. Besides the more usual pyroxenic rocks, there are specially basic varieties, including one which contains magnetite to the extent of one-fifth of its mass.

Brögger next considers the evidence as to the order of succession in time of the various Triassic igneous rocks of the district, a point upon which very different opinions have been held. His conclusions are briefly summarised thus:

(i.) The earliest eruptions are represented by basic dyke-rocks and lavas (melaphyres, augite-porphyrites, plagioclase-porphyrites, amygdaloids, tuffs, etc.)

(ii.) To the later eruptions of the basic dyke-rocks and lavas correspond

also basic plutonic rocks, of which, however, only a small part (pyroxenites) are preserved as marginal facies of somewhat more acid rocks.

(iii.) These more acid rocks (monzonites) are of intermediate composition, and belong to a distinct group, that of orthoclase-plagioclase-rocks. Their composition is represented in lava-form by certain plagioclase-porphyrites on the Mulatto, etc.

(iv.) Younger than the monzonites and the rocks corresponding to them are red biotite-granites (with a marginal facies of tourmaline-granite) near Predazzo. With these should perhaps be included, not only small veins of aplite, etc., at the immediate boundary of the granite, but also dykes of quartz-porphyry at a greater distance, which were formerly placed with the so-called liebenerite-porphyries.

(v.) The latest eruptions are represented by an assemblage of dykes of small size ; partly of ultrabasic composition and rich in iron (camptonites, etc.), partly of intermediate composition and poor in iron (liebenerite-porphyries, here styled nepheline-bostonite-porphyries).

The author next discusses the question of the mechanics of plutonic masses, and especially the probable form of the partly concealed bodies of granite and other deep-seated igneous rocks in general. He criticises adversely the theories of Kjerulf and Michel Lévy, according to which such masses are supposed to extend downward to indefinite depths, and to have assimilated or incorporated large tracts of the strata which they displace ; and he argues that the general form of large intrusions must be comparable with that of laccolites. His illustrations are drawn mainly from the Christiania district, and his conclusions on this point are summarised thus :—The plutonic rocks of the Christiania district have been brought into their present position by purely mechanical processes, having been squeezed up and intruded laterally in consequence of a great sinking in of the neighbouring parts of the earth's crust : their composition is not essentially influenced by assimilation of the bounding rocks or melting in of the cover, but is the final result of the processes of differentiation in the original magma of the common magma-basin from which they all originate. Their typical form, apart from their frequent lateral termination along vertical fault-planes, is the cake-form of the laccolite. This conclusion is extended to the Tirol and to other regions which have not been affected by regional metamorphism.

A comparison follows between the chronological succession of eruptive rocks in the Southern Tirol and in the Christiania district. For this purpose Brögger includes with the Monzoni and Predazzo rocks the tonalitic masses of Re di Castello, Monte Aviolo, and Adamello, the

granite of Brixen, the tonalite of the Riesenferner, and other rocks which there is reason to believe are of Triassic age and belong to the same eruptive region. The progress of differentiation and the mechanism of eruption seem to have followed similar lines in the two districts, although the original magma of the Tirolese basin must have been considerably poorer in alkalies, richer in lime, and different in other respects from that of Christiania.

The last chapter deals with the rather scanty data as to the sequence of eruption of plutonic rocks in other districts. The conclusion reached is that the order "basic, less basic, acid" seems in fact to be so often repeated among the plutonic rocks, that we must regard it as the normal one: the sudden reversion to basic again is found in many cases, but appears to be as often absent. A. H.

Lawsonite, a new mineral (F. L. Ransome, *Bull. Dept. Geol. Univ. California*, I, 301-312, 1895). Lawsonite occurs as a rock-forming mineral in a crystalline schist at the Tiburon Peninsula, Marion Co., California, as large tabular crystals embedded in margarite veins, and as crystals of octahedral or prismatic habit lining and filling cavities. The crystals are orthorhombic, with the forms c(001), b(010), m(110), d(011) and d'(041); the octahedral crystals have m and d equally developed, and the tabular crystals (tabular parallel to c) are often much elongated parallel to one of the edges $c : m$; the faces are deeply striated; twinning on m(110) is common; $a : b : c = 0{\cdot}6652 : 1 : 0{\cdot}7385$; $mm' = 67°16'$, $dd' = 72°53\frac{1}{2}'$. Cleavage b (010) perfect, c (001) less perfect, m (110) indistinct. The small crystals when fresh are clear and colourless, but the larger are of a grey-blue colour of unequal distribution in zones and bands, much resembling cyanite. The plane of the optic axes is b(010), the acute bisectrix being perpendicular to c(001), optically positive; for sodium light, $2V = 84°6'$, $\alpha = 1{\cdot}6650$, $\beta = 1{\cdot}6690$, $\gamma = 1{\cdot}6840$. Strongly pleochroic in the coloured portions, the colour varying from blue to colourless or faint yellow. Hardness about 8; brittle; sp. gr. 3·084 (in powder 3·091). Easily fusible. The mineral is only slightly acted upon by boiling in strong hydrochloric acid, but is completely decomposed by hydrochloric acid in a sealed tube at 140°. Analysis gave

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	H_2O	Total.
38·10	28·88	0·85	18·26	0·23	0·65	11·42	98·39

At 225° there is a loss of only 0·1 per cent. Formula, $H_4\,Ca\,Al_2\,Si_2\,O_{10}$, or as a basic metasilicate $2Al(OH)_2.Ca(SiO_3)_2$; this is similar to

carpholite, H_4 Mn Al_2 Si_2 O_{10} (monosymmetric?), with which lawsonite is probably isomorphous, the prism angles of the two minerals being nearly equal. The associated minerals of the schist are margarite, epidote, actinolite, glaucophane and red garnet, these varying considerably in distribution, so that the colour of the rock is green, blue, yellowish-green, or red. L. J. S.

Optical Properties of Lithiophilite and Triphylite. (S. L. Penfield and J. H. Pratt, *Amer. Journ. Sci.*, L. 387-390, 1895.) As iron replaces manganese in the passage from lithiophilite (Li Mn PO_4) to triphylite (Li Fe PO_4), it is shown that there is an increase in the refractive indices and a gradual change in the size of the optic axial angle, as is seen in the following table, which gives part of the measurements obtained for sodium light.

Locality.	FeO %.	β.	$2V$ over b.	Plane of optic axes.
Branchville, Conn.	4·24	1·675	65° 13′	(001)
Do.	9·42	1·679	62 54	(001)
Do.	13·63	1·682	56 4	(001)
Grafton, N. H.	26·58	1·688	0°	Uniaxial
Rabenstein, Bavaria	35·05	1·702	120°	(100)

The optically positive mineral from Grafton has for thallium light $2V = 21°53'$ in the plane (001), and for lithium light $2V = 15°3'$ in the plane (100). Lithiophilite is optically positive, and the acute bisectrix is perpendicular to (010); the Rabenstein triphylite is optically negative, and the acute bisectrix is perpendicular to (001). On plotting a curve it is seen that a further increase in the amount of iron would cause 2V to become zero again, this time negative with the optic axis perpendicular to (001); and as the pure compound Li Fe PO_4 (which is not known) is approached, it may be expected that the optic axes would open out in the plane (010). L. J. S.

Knopite, a new mineral resembling Perofskite, from Alnö, Sweden. (P. J. Holmquist, *Geol. För. Förh.*, XVI., 73-95, 1894; abstr. in *Neues Jahrb. Min.*, II. 412-416, 1895.) Minerals at first thought to be perofskite and dysanalyte are here described under the new name knopite, of which two types are distinguished.

Type I. This is found as lead-grey crystals of metallic lustre, about 5 mm. across, in crystalline limestone from Långörsholm, and is associated

with garnet, titano-magnetite, dark green mica and apatite; it also occurs in the serpentine-like masses enclosed in the limestone. The crystals are pseudocubic, and show dull octahedral faces with smaller cube faces which are bright and often conically rounded: there are also small rounded faces between the positions of (811) and (12.1.1), and between (11.2.0) and (920). On the cube faces are seen striations due to the lamellar structure of the crystals, which is well brought out in sections cut parallel to various faces, when viewed by reflected light falling from one side, and resembles that seen in perofskite by transmitted light: the broader lamellæ are perpendicular to (100) and (111), these being built up of finer lamellæ perpendicular to (100) alone. A platy fracture often parallel to (100) is seen in the sections. Very thin sections are translucent and strongly doubly refracting, an eccentric optic axis being seen in places through (100). Fresh crystals have a hardness of 5—6, fracture uneven; sp. gr. of the crystals 3·8902, of the purified powder 4·1101. The mineral is decomposed by a mixture of hydrofluoric and sulphuric acids. Analysis gave:—

SiO_2	TiO_2	ZrO_2	FeO	MnO	MgO	Y—earths(?).	Ce_2O_3	CaO	K_2O	Na_2O	H_2O	Total.
1·29	58·74	0·91	3·23	0·31	0·19	0·06	5·80	26·84	0·75	0·29	1·00	99·41

This reduces to RO,TiO_2; ZrO_2 replacing TiO_2, while the silica is considered as an impurity.

Type II. This occurs in the Långörsholm limestone, and also in a breccia, from the nepheline-syenite margin at Norrvik, consisting mainly of serpentine-like masses with apatite, nepheline and some calcite. The small black cubes of knopite have a metallic lustre and show a step-like aggregation; (111) is small, and interpenetrating twins on (111) occur. No lamellar structure is seen on the cube faces. Very thin splinters are translucent, doubly refracting, and pleochroic, and show only traces of lamellæ. H = 5-6, fracture uneven. The mineral from Norrvik has sp. gr. = 4·21 (anal. I.), that from the limestone has sp. gr. = 4·288 (anals. II and III).

	TiO_2	FeO	Ce_2O_3	MgO	CaO	Na_2O K_2O	H_2O	Total.
I.	54·12	4·19	6·81	—	33·32	0·79 0·38	0·21	99·82
II.	56·30	5·15	4·46	0 35	32·22	0·39	0·30	99·17
III.	54·52	4·94	4·42	0·32	32·84	1·68	0·92	99·64

The slight variation from the formula RO. TiO_2 is explained by impurities (especially water and alkalies) and decomposition. L. J. S.

Northupite, a new mineral (W. M. Foote, *Amer. Journ. Sci.*, L., 480-481, 1895). This was found by C. H. Northup in clay at Borax Lake

California, as regular octahedra of a dirty white to dark brown colour. Cleavage imperfect; brittle, with uneven fracture, H = 3·5-4. These are regularly arranged enclosures, probably of organic matter. When heated the mineral blackens and easily fuses. Qualitative analysis shows it to be a double chloride and carbonate of sodium and magnesium, together with traces of phosphoric acid, silica, iron, calcium and organic matter. Boiling water decomposes the mineral, with separation of basic carbonate of magnesium. L. J. S.

Jadeite from Tammaw, Upper Burma (Max Bauer, *Records Geol. Survey India*, XXVIII. 91, 1895, and *Neues Jahrb. Min.*, I., 18-27, 1896). The jadeite of this locality is snow-white with emerald-green spots, the latter containing chromium; sp. gr. varies from 3·338 to 3·325. Analysis by K. Busz gave

SiO_2	Al_2O_3	CaO	MgO	Na_2O	Loss on ignition	Total	Sp. gr.
58·46	25·75	0·63	0·34	13·93	1·00	100·11	3·332

Chromium and iron are absent. This corresponds to 90·1 p.c. of Na_2O, Al_2O_3, $4SiO_2$, 4·59 of MgO, Al_2O_3, $4SiO_2$ and 1·28 of CaO, SiO_2. Under the microscope it is seen to consist of a confused aggregate of irregular prisms with slight pleochroism, and the cleavage and optical characters of pyroxene; extinction angle 40°. Some specimens show marked cataclastic structures, the prisms being bent, fringed at the ends, and showing undulose extinction; sometimes the whole is crushed to small grains with aggregate polarisation. This is associated with secondary twinning on the basal plane, the lamellæ being narrow and numerous, and the mineral closely resembling plagioclase in appearance. L. J. S.

Native Iron from Ontario (G. C. Hoffmann, *Report Geol. Survey Canada*, VI. R. 23-24, 1895). Native iron occurs as small steel-grey spherules in kaolin and limonite in a pegmatite vein at Cameron, District of Nipissing. The spherules are almost perfectly spherical, and vary in size from 1 mm. in diameter down to microscopic dimensions; they are very hard, scratching hardened steel. When dissolved in hydrochloric acid there is a strong smell of phosphine. Analysis by R. A. A. Johnston gave—

Fe	Mn	Ni	Organic matter.	Insol.	Total	Sp. gr.
90·45	0·75	trace	not det.	7·26	98·46	7·257

Copper and cobalt are absent. The insoluble residue consists of the light brownish nuclei, which have an apparently concretionary structure: it contains 88·77 p.c. of SiO_2 with some Al_2O_3, Fe_2O_3 and CaO. The metallic layer of these spherules is rather thicker than that of the similar spherules from St. Joseph Island, Ontario (Abstr. Vol. X., 50). L. J. S.

Prolectite, a new mineral of the Humite group (H. Sjögren, *Bull. Geol. Inst. Upsala* II. 99-105, 1894). Penfield and Howe have shown (*Amer. J. Sci.* XLVII. 188, 1894) that the members of the humite group have the composition—

Chondrodite	... ...	$Mg_3[Mg(F,OH)]_2[SiO_4]_2$
Humite	... ...	$Mg_5[Mg(F,OH)]_2[SiO_4]_3$
Clinohumite	... ...	$Mg_7[Mg(F,OH)]_2[SiO_4]_4$

In these formulæ the ratio of the number of magnesium atoms is 5 : 7 : 9, and this is also the ratio of the vertical axes of the three minerals, which thus form a morphotropic series. The same authors also predicted the existence of a member of the group having the composition $Mg[Mg(F, OH)]_2SiO_4$, and crystallising either in the orthorhombic or monosymmetric system, with $\beta = 90°$ and $a : b : c = 1·086 : 1 : 1·887$. Later (*Bull. Geol. Inst. Upsala*, II, 39, 1894) Sjögren also deduced the same formulæ as above for the chondrodite, humite and clinohumite of the Ko-mine, Nordmark, Sweden. The occurrence and associations of the humite minerals at this new locality are strikingly similar to those at the Tilly Foster iron mine, N.Y., and in the description (*Bull. Geol. Inst. Upsala*, I. 40, 1892) of their crystallographic and optical characters, Sjögren mentions that some crystals, which are the subject of the present paper, differ from the rest in crystal angles and optical properties. Of these crystals only two fragments were found, which are here described as being monosymmetric with $a : b : c = 1·0803 : 1 : 1·8862$; $\beta = 90°$; the vertical axis is thus one-third of that of clinohumite, and the axial ratios are almost exactly the same as those predicted by Penfield and Howe for a mineral having the composition $Mg[Mg(F,OH)]_2SiO_4$. Owing to lack of material an analysis has not been made of this interesting mineral, which derives its name from προλέγειν, to foretell (see above p. 189).

L. J. S.

Hoeferite, a new mineral of the Chloropal group (F. Katzer, *Tsch. Min. Mitth.*, XIV., 519-525, 1895). This new mineral from Kritz, near Rakonitz, Bohemia, is earthy, and of a siskin-green colour with a fatty

lustre, H = 1–3. It fuses with difficulty to a black magnetic slag; it is only partially decomposed by strong sulphuric acid, and not at all by HCl or KOH. The material, which contains small quantities of iron sulphate, antimony ochre and arsenic sulphide, was purified by means of dilute acid, and, after being air-dried, gave on analysis—

SiO_2	Fe_2O_3 (and a little FeO)	Al_2O_3	Loss on ignition	Total	Loss at 120°	Sp. gr.
36·14	45·26	1·11	18·15	100·66	0·99	2·27
35·88	46·64		18·20	100·72	3·79	2·41

Formula $2Fe_2O_3.4SiO_2.7H_2O$. The points in which the mineral differs from nontronite, pinguite and other chloropals, are given. Schrauf's analysis of chloropal from Mugrau is reduced to a mixture of hoeferite and $CaO.3SiO_2.4H_2O$. The mineral from Kritz is supposed to have been produced by the action of sulphuric acid, derived from pyrites, on felspar. L. J. S.

Hautefeuillite, a new mineral (L. Michel, *Bull. Soc. Franc. Min.*, XVI., 38-40, 1893). The greyish-white apatite veins in the gabbro of Odegärden contain greenish nodules consisting of a mixture of wagnerite and apatite, in which the new mineral was found with crystals of apatite, pyrites and monazite. The colourless, transparent, monosymmetric crystals form lamellar and radial aggregates; they show the forms 100, 110 and 010, and have a perfect 010 cleavage. Plane of the optic axes, 010, $Bx_a : 100 = 45°$ about; $\beta = 1·52$; $2E$ about 88°; $2V$ 54°23′ for yellow. Sp. gr. 2·435; H 2½.

P_2O_5	MgO	CaO	H_2O	Total.
34·52	25·12	5·71	34·27	99·62

This gives the formula $(Mg,Ca)_3(PO_4)_2$, $8H_2O$. The mineral differs from bobierrite in containing calcium, and in the optical characters.

L. J. S.

Caryinite and Soda-berzeliite (H. Sjögren, *Bull. Geol. Inst. Upsala*, II., 113-121, 1894). The only previous analyses of *caryinite* have been shown to have been made on impure material, mixed with calcite and berzeliite, into the latter of which caryinite is readily altered. A new find of the mineral at the old locality, Långban, Sweden, has rendered it possible to analyse pure, fresh material, and to determine, by means of the cleavage (110 and 010) and optical characters, that the mineral is

orthorhombic. The massive nut-brown mineral occurs in fissures with schefferite, rhodonite and hedyphane ; sp. gr. 4·29 ; analysis by Mauzelius gave the composition I.—

	As_2O_5	V_2O_5	P_2O_5	PbO	FeO	MnO	MgO	BaO
I.	49·78	trace ?	0·19	9·21	0·54	18·66	3·09	1·03
II.	52·90	0·24	—	—	0·38	21·41	0·72	—

	CaO	K_2O	Na_2O	H_2O	Cl	Total
I.	12·12	0·37	5·16	0·53	trace	100·68
II.	18·34	0·09	5·05	0·40	trace	99·53

Analysis II is of *soda-berzeliite*, a new variety of berzeliite, and only distinguished from it in outward appearance by its orange-yellow to fire-red colour ; it is usually massive, but sometimes occurs as regular icositetrahedra ; sp. gr. 4·21 ; it contains also traces of Sb_2O_5. These two analyses are very similar, and both reduce to the same formula. If the water exists with the bases as H_2 the formula is deduced as $10RO,3As_2O_5$; if, however, it exists in the group (HO-R″) the formula is $3RO,As_2O_5$. These two minerals may then have different formulæ, or they may have the same formula and be dimorphous, or thirdly, the presence of lead in caryinite may be essential. L. J. S.

Pyronurite from the Moss Mine, Nordmark, Sweden (H. Sjögren, *Bull. Geol. Inst. Upsala*, II, 59-63, 1894). This mineral, which has only been previously described from Långban and from the Shetlands, has been found in the manganiferous dolomite of the Moss mine, as thin, yellow to yellowish-brown, crystal scales with a round or hexagonal outline, and with a pearly to greasy lustre on the basal plane. The forms present are 111, 100, $2\bar{1}\bar{1}$, $5\bar{1}\bar{4}$, and others giving rise to rounding; $100 : 111 = 76°30'$ ($a : c = 1 : 3·6072$). These angles are very near to those of chalcophanite, but as the prism $5\bar{1}\bar{4}$ is only developed with six faces, the crystals are hexagonal with pyramidal hemihedrism, chalcophanite being rhombohedral. Only in very thin crystals is there total extinction and an optically uniaxial figure, other crystals being divided into fields which give biaxial figures. On heating, the mineral is infusible and retains its yellow colour ; after ignition it is strongly magnetic, before only slightly so. Sp. gr. 2·07. Analysis by Mauzelius, on a small amount of material dried at 108°, gave

Fe_2O_3	MnO	MgO	H_2O	Insol.	Total
22·0	4·5	34·8	36·1	0·5	97·9

This nearly agrees with the pyroaurite formula, but with part of the MgO replaced by Mn; namely $Fe_2O_3.6(Mg,Mn)O.15H_2O$. The Långban mineral is opaque under the microscope, indicating decomposition, which is also shown by the presence of carbon dioxide. L. J. S.

Artificial Powellite (L. Michel, *Bull. Soc. Franc. Min.* XVII, 612-614, 1894). On heating to a high temperature a mixture of six parts of sodium molybdate, one of sodium tungstate, three of calcium chloride and two of sodium chloride, translucent, milky-white crystals of powellite were formed; these, which are about 2 mm. across, are octahedral in habit, with the forms $c(001)$, $p(111)$ and $e(101)$; $a : c = 1 : 1{\cdot}5449$. The crystals have an adamantine lustre and are optically positive; analysis gave

MoO_3	WO_3	CaO	Total	Sp. gr.	
62·37	10·23	26·41	99·01	4·61	L. J. S.

Artificial Percylite, Cumengeite and Boleite. (C. Friedel, *Bull. Soc. Franc. Min.*, XV, 96-101, 1892, and XVII, 6-8, 1894.) In the first paper is described the result of the prolonged action of copper chloride solution on lead hydroxide; here a blue crystalline powder was formed, consisting of strongly birefringent tetragonal octahedra having the characters of the tetragonal boleite; with these, but in much smaller quantity, were also cubic crystals corresponding to the cubic variety of boleite. Analysis of the material agreed with the formula Pb(OH)Cl, Cu(OH)Cl, and the name percylite is here given (apparently to both kinds of crystals) to distinguish it from the argentiferous boleite. Subsequently, however, Mallard (*Bull. Soc. Franc. Min.*, XVI, 184, 1893), has given the name cumengeite to the former crystals, though the cubic crystals may still perhaps be considered as being percylite. Phosgenite was also formed in the above reaction. In the experiment described in the second paper a mixture of lead and silver hydroxides, in the same proportion as in boleite, together with clay, took the place of the lead hydroxide; the action of the copper chloride was in this case much slower, and at the end of several months the clay was found to contain blue cubic crystals, blue spherules, and grains of pyrites. The crystals were built up exactly like certain crystals of boleite, consisting of an isotropic cubic nucleus surrounded by six truncated tetragonal pyramids. The crystals were too small in quantity and too impure for analysis, but they certainly differ from those formed without the intervention of silver, and are to be considered as boleite. L. J. S.

Boleite from Broken Hill, N.S.W. (A. Liversidge, *Journ. and Proc. Roy. Soc. N.S.W.*, XXVIII, 94, 1894). Boleite has been found at the Broken Hill South Mine associated with hæmatite and quartz; it occurs as cubes of an indigo-blue colour with a strong vitreous lustre. Small {111} and {110} planes are also present, and there is a nearly perfect cubic cleavage, as well as an imperfect octahedral cleavage. The cubes measure 4—7 mm. along the edge, and interpenetrate like cubes of fluor-spar. Brittle, H = $3\frac{1}{2}$; sp. gr. = 5·02.

Analysis by Carmichael and Armstrong gave:

Ag	Pb	Cu	Cl	O (calcd.)	H_2O (calcd.)	Total.
8·25	47·20	19·20	13·50	[6·10]	[5·44]	99·69

This agrees closely with the analysis of the original boleite. A direct determination of the water by Liversidge gave 6·39 per cent., which may be a little too high. L. J. S.

Origin and composition of Onyx Marbles (G. P. Merrill, *Smithsonian Report (U.S. National Museum) for* 1893-4, 539-585, plates 1-18, 1895). Certain travertines and cave deposits of calcium carbonate, which are characterised by being banded and translucent are the so-called onyx marbles or oriental alabasters; they are here shown (by their specific gravity) to consist in almost all cases of calcite, and not of aragonite. Although it is known that such substances are deposited from solution on loss of carbon dioxide, it is not known what controls (except it be the rate of deposition) the character of the deposit as regards compactness and condition of crystallisation, the result being sometimes a compact marble, sometimes a light, tufaceous sinter. The true onyx marbles are superficial deposits from hot springs, and, according to the view taken by the author, deposition has taken place slowly at the bottom of pools of water. The compact nature cannot be explained by the subsequent metamorphism of loose tufas, as such tufas alternate with the marbles. Cave marbles (*i.e.* stalactites, &c.) differ from travertines in being cold water deposits, and in being of greater purity, the water having contained only calcium carbonate in solution, which is not the case with hot springs. These consist sometimes of radially fibrous aragonite, sometimes of silky lustre, but more commonly of calcite, which is of a more granular texture than the aragonite: sometimes both minerals occur in the same cave, but they then belong to different periods of deposition.

In the onyx marbles the content of $CaCO_3$ is rarely below 90 per cent., iron oxide and carbonate being the next prominent constituents, these

being the main cause of the wide range in colour. The pale and green colours are associated with ferrous carbonate, and the red-browns with ferric oxide, which latter has been produced by the oxidation of the carbonate along cracks and joints; *e.g.* a green marble with 4·27 per cent. $FeCO_3$, contained in the brown-red (oxidised) portions 1·22 per cent. $FeCO_3$ and 3·53 per cent. Fe_2O_3. Some of the colour variations may be partly due to manganese, and in some amber brown and yellow marbles (and one rose-coloured) and in all stalactitic marbles, they are due to organic matter; they are rarely due to mechanical enclosures, such as clay. Small quantities of calcium phosphate and sulphate and $BaCO_3$ and $SrCO_3$ are sometimes present.

The marbles are holocrystalline, sometimes granular, but more often fibrous or radially columnar in structure, the length of the fibres being parallel to the principal axis of calcite, and arranged perpendicularly to the planes of deposition (*i.e.* banding). The specific gravity varies from 2·64 to 2·79 and the hardness 3 to 3·5; only in one case was the sp. gr. as high as 2·87, with H = 4, this being the only aragonite in the whole series examined. The uses, ancient and modern, and the occurrences of onyx marble, are described at length in the paper.

L. J. S.

Kauaiite, a new mineral from Hawaii. (E. Goldsmith, *Proc. Acad. Nat. Sci. Philadelphia*, 1894, 105-107). This volcanic product is white or faint cream coloured, and is dull and powdery, closely resembling chalk in appearance. Under the microscope it is seen to consist of granules all of about the same size, and is pale blue by transmitted light. Sp. gr. 2·566. When heated it gives off an oily substance and acid water. It is soluble in acids only after ignition, but is dissolved by caustic alkali. Eliminating about 5·94 per cent. of carbonaceous matter, the results of the analysis are:—

Al_2O_3	K_2O	Na_2O	H_2O	SO_3
39·79	7·37	1·72	33·56	17·55

This gives the formula $2Al_2O_3,3(K,Na,H)_2O,SO_3$ This highly basic sulphate is distinguished from others by being insoluble in acids.

L. J. S.

Retzian (Hj. Sjögren, *Bull. Geol. Inst. Upsala*, II, 54-59, 1894). This new arsenate occurs as crystals in cavities in a mixture of braunite and dolomite at the Moss mine, Nordmark, Sweden. It is of a chestnut to

chocolate-brown colour ; streak light brown ; lustre vitreous, approaching to greasy ; subtranslucent. The crystals are orthorhombic with a prismatic for thickly tabular habit ; forms, in order of prominence, $b(010)$, $c(001)$, $m(110)$, $d(101)$, $n(130)$. There is no cleavage. The plane of the optic axes is parallel to b ; strongly pleochroic, the colour varying from crimson to orange-yellow. Sp. gr. 4·15 ; H about 4. The analysis is incomplete owing to lack of material ; a constituent (amounting to 10·3 per cent.), separated from the manganese precipitate, not having been identified.

As_2O_5	PbO	FeO	MnO	CaO	MgO	SiO_2	H_2O	Insol.
24·4	0·2	1·7	30·2	19·2	2·7	0·5	8·4	4·3

From this analysis it is seen that the mineral is closely allied to other hydrous manganese arsenates (allactite, synadelphite, diadelphite, hæmafibrite) from the same mine, and to flinkite from the Harstig mine ; none of these, however, contains any calcium. Of these it comes nearest to allactite (monosymmetric) and hæmafibrite (orthorhombic) in not containing Mn_2O_3 or other sesquioxides, but the crystallographic constants and strong pleochroism distinguish it from the latter. The ratios of the parameters come near to those of flinkite, but there is a difference in the optic orientation of the two minerals. L. J. S.

Urbanite, a new Pyroxene (Hj. Sjögren, *Geol. För. Förh.*, XIV, 251-3, 1892; and *Bull. Geol. Inst. Upsala*, II, 77-87, 106-8, 1894). The mineral, which occurs as veins in hæmatite at the Långban mines, Sweden, was first examined by Breithaupt in 1865, it being then considered to be identical with the schefferite from the same locality. In drusy cavities brilliant brownish-black or black crystals have been found ; these present, as more important forms, $a(100)$, $b(010)$, $m(110)$, $u(111)$, $s(11\bar{1})$, $r(053)$; $c(001)$ being absent : the predominating forms u and s give rise to an octahedral habit, which is very different from that of schefferite or of iron-schefferite.

$$a : b : c = 1{\cdot}1009 : 1 : 0{\cdot}6058 \; ; \; \beta = 72°7'$$

These constants indicate an approach to acmite rather than to schefferite, as also do the optical constants, the extinction angle $a : c'$ on b being 16° in the obtuse axial angle β. There is the usual prismatic cleavage of pyroxene, with one parallel to the base, $c(001)$, less distinct. The crystals are somewhat translucent : streak light-brown. The pleochroism is strong, the colour varying from brown to light-yellow.

Sp. gr. 3·52. The analysis I corresponds to the metasilicate formula $(Ca,Mg)O,SiO_2+Na_2O,Fe_2O_3,4SiO_2$, the first part representing diopside and the second part acmite. The high percentage of Fe_2O_3 and of alkalies distinguishes the mineral from schefferite.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O
I. Långban	51·61	—	0·74	27·24	0·54	1·73	4·90	2·75	0·36
II. Glakärn	49·21	0·06	1·27	25.35	0·50	6·71	5·68	1·39	0·40

	Na_2O	H_2O	F	Loss on ignition (probably water)	Total
I.	10·59	—	—	0·90	101·36
II.	8·95	1·05	0·20	—	100·69

Igelström's "*lindesite*" from the Glakärn Mine, Örebro (*Abstr.* XI, 105), has been re-analysed by Mauzelius, whose results are given under II, from which a similar formula to the above is deduced, namely $(Ca,Mn)O.SiO_2+Na_2O.Fe_2O_3.4SiO_2$; this represents a rhodonite with an acmite molecule. The mineral occurs at this locality as chestnut-brown coloured grains in a mixture of rhodonite and felspar, which forms veins in the manganese ores jacobsite and braunite. There are two distinct cleavages, with an angle of approximately 96°30′, and also one less distinct. The optical properties are as before; extinction angle $a : c' = + 22°$. Sp. gr. 3·53. L. J. S.

Lorandite. (J. A. Krenner, *Math. és Természett. Értesitö*, XII, 471, 1894, and *Ber. aus Ung.*, XII. 262, 1895). A short notice of this new mineral has already appeared (XI, 32). The tabular or short prismatic crystals are of a cochineal to kermesite-red colour, they are transparent, and can be bent like selenite.

$$a : b : c = 0{\cdot}85339 : 1 : 0{\cdot}66500\,; \quad \beta = 90°17'$$

Forms: (100) (001) (120) (540) (101) (10$\bar{1}$) (011) (111) (11$\bar{1}$) (12$\bar{1}$) (321) (545) (52$\bar{1}$) (54$\bar{1}$). The cleavage is 10$\bar{1}$, perfect, and 101 and 100 very good. Analysis gave:—

S.	As (calcd. from loss).	Tl.
19·02	(21·47)	59·51

Formula $TlAsS_2$. Occurs on realgar at Allchar, Macedonia; rare.

L. J. S.

Xiphonite, a new amphibole from Etna. (G. Platania, *Atti e rendiconti dell' Accad. di Scienze &c., di Acireale*, N. Ser. V, 55-62, 1893;

abstract in *Neues Jahrb. Min.*, II, 236, 1895). This occurs as small, honey-yellow transparent crystals, in the drusy cavities of a slaggy lava. It is monoclinic with the forms $a(100)$, $b(010)$, $c(001)$, $m(110)$, $e(130)$, $x(150)$, $t(101)$, $p(\bar{1}01)$, $r(011)$, $i(031)$; $mm = 53°15'$. The crystals are prismatic in the direction of r; cleavage m distinct. Plane of the optic axes b; extinction angle 13°. It is supposed, together with the accompanying hæmatite, to have been formed by sublimation. On account of the feeble pleochroism, the light colour, and the special mode of occurrence, it is considered to be a distinct variety of hornblende.

L. J. S.

Instructions for the Use of Plates I. and II., representing some Nets for Homogeneous Structures.

(1) Several copies of every figure should be made, and each of these after being cut out, should be folded along the dotted lines, and fitted up so as to form a regular solid.

(2) The similar solids thus obtained should be fitted together symmetrically without interstices.

Fig. 1.

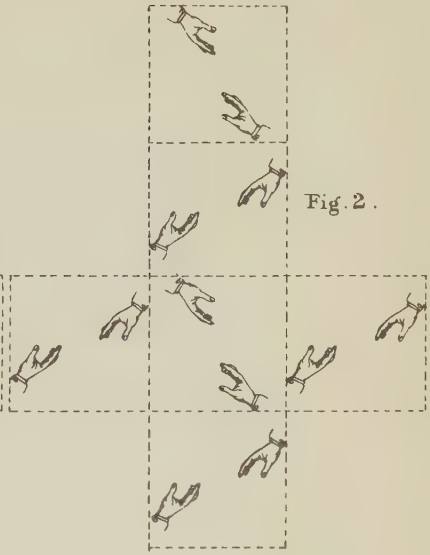


Fig. 2.

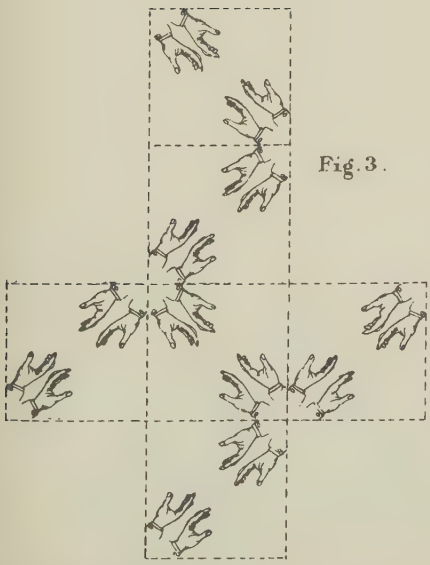


Fig. 3.

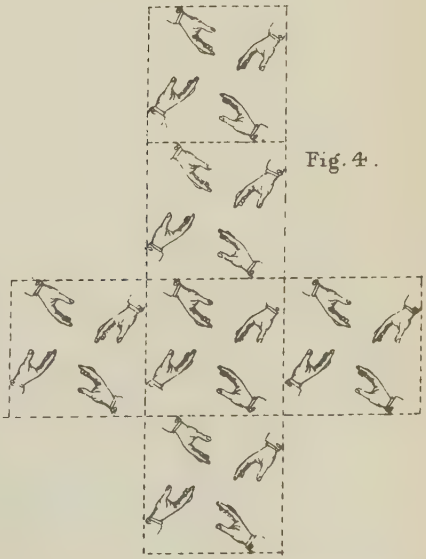


Fig. 4.

W. Barlow del.

Mintern Bros. lith.

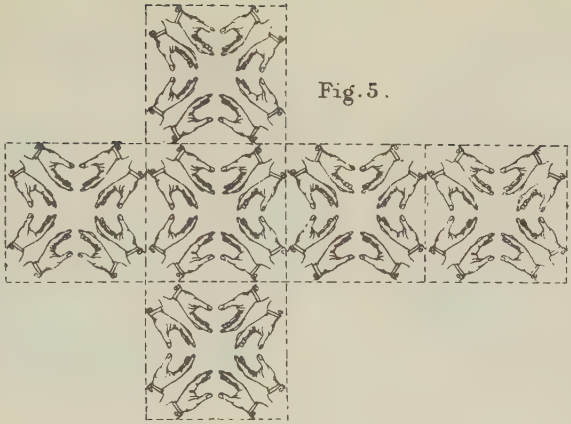


Fig. 5.

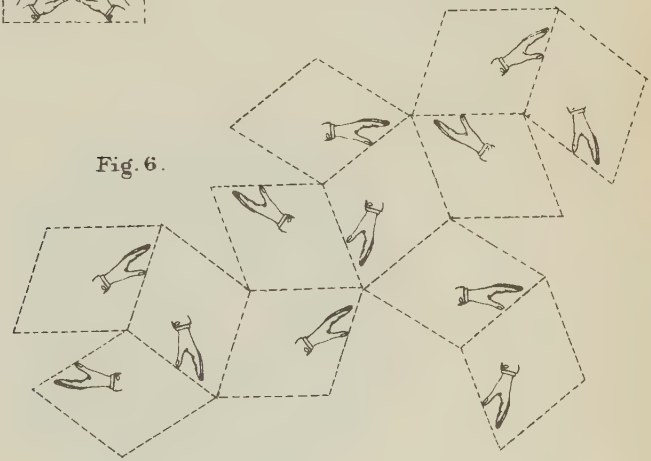


Fig. 6.

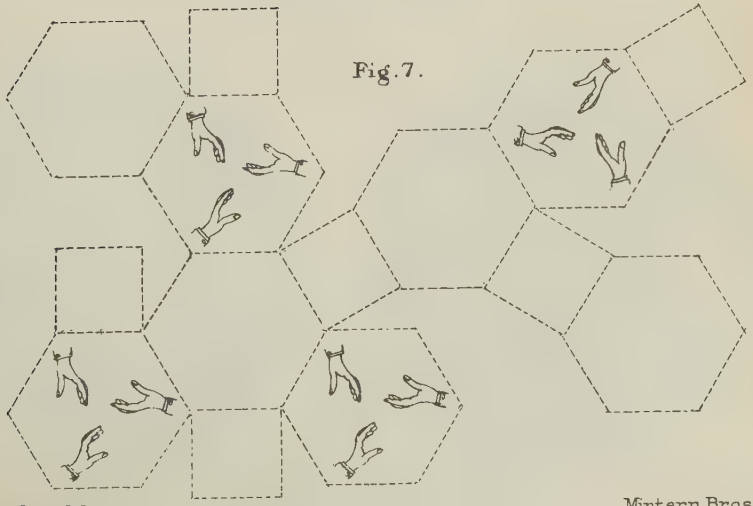


Fig. 7.

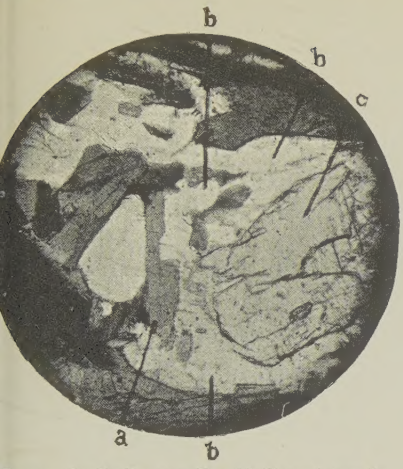


Fig. 1.—Cordierite, corroding biotite and cyanite.

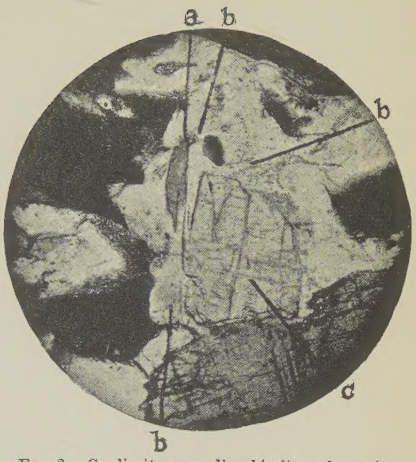


Fig 2.—Cordierite, corroding biotite and cyanite.

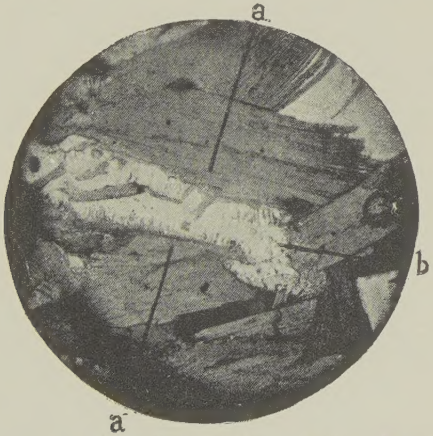
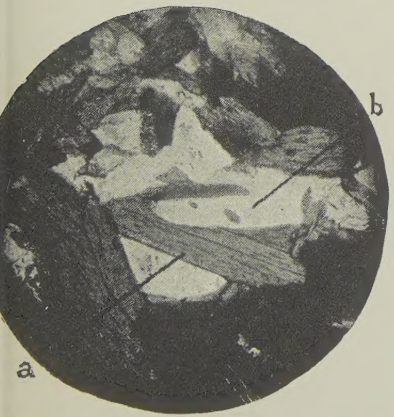


Fig. 3.—Cordierite intrusive in biotite.



g. 4.—Cordierite corroding and cutting obliquely across laminæ of biotite.

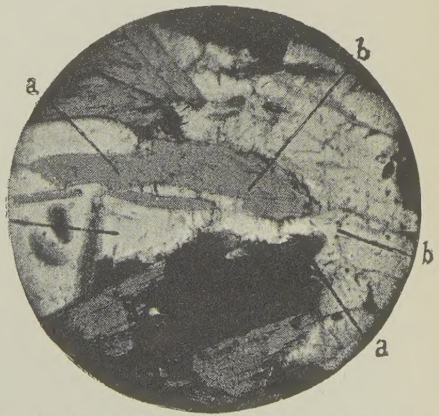


Fig. 5.—Cordierite, corroding and intruding into biotite.

(*a*) Biotite. (*b*) Cordierite. (*c*) Cyanite.

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